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Integrated Research to Improve Fire Management Decisionmaking

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Abstract

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The emergence of large fires of long duration (also known as siege fires) with their inherently high costs has raised numerous questions about the opportunities for cost containment. Cost reviews from the 2003 fire season have revealed how additional knowledge created through research can lead to better management and lower costs of fire incidents.

Keywords: Fire management, decisionmaking, strategic planning.

Contents

Introduction

The purpose of this report is to describe how the fire management community can be supported by research and how short- and long-term programmatic research can be guided by the needs of fire management. The report has been developed from the perspective that effective fire management requires a strong research base that directly reflects the challenges and problems experienced in the field. To this end, the report focuses on specific immediate and long-term needs and challenges within the fire management community that can be addressed by focused research activities. Many of these needs relate to aspects of fire management decisionmaking, including risk assessment and risk management.

This report has been developed from the perspective that effective fire management requires a strong research base that directly reflects the challenges and problems experienced in the field.

The fire management community today faces many difficulties, a comprehensive review of which is not possible here. The authors have backgrounds in fields of research that give them a perspective on fire management from which they can identify some of the current problems within the fire management community and frame those problems in terms of potentially useful and productive research activities. By useful and productive, we mean research activities that have as their endpoints direct relevance to the needs of the field personnel and that are amenable to technology transfer and field application.

As part of grounding this report in the current needs of fire management, we participated in two field-related activities that gave us the opportunity to see more clearly how the fire management community approaches its work and where research may provide valuable assistance and support.

One activity involved participation on a fire review team that examined the Northern Area Operations of the Pacific Southwest Region (Region 5) Fire and Aviation Management from August 31 through September 8, 2003 (USDA FS 2003b). An intense lightning event during this period ignited multiple fires throughout the Northern California Geographical Area (Region 5). This provided an opportunity to review the management of a large aggregate of incidents, which had not been done previously. A review team was assembled on September 8, 2003, to examine the overall preparedness within the Northern California Geographic Area immediately before and during the lightning event, the effectiveness of fire suppression operations during the aggregate of incidents, the prioritization process, line officer involvement, cost efficiencies, and to document any issues affecting fire and aviation organizations during fire activity.

A second activity involved participation on the Large Incident Strategic Decision and Assessment Oversight Review Team for the B&B Complex Fires that occurred in the Pacific Northwest Region (Region 6) during August and September, 2003 (USDA FS 2003a). This review examined the strategic decisions made by the incident and area command teams in relation to the local land management plan (LMP), Wildland Fire Management Policy, and Wildland Fire Situation Analysis (WFSA), a computerized decision-support tool. Also examined were the delegation of authorities and the extent that cost containment is a part of any delegation, and how financial oversight was provided. The review evaluated incident costs with respect to strategic decisions, political and social issues, and use of personnel and equipment.

Many issues in fire management were identified as part of these reviews, and from our perspective, these reviews provided a partial basis for identifying where and how research might provide additional improvements to operational effectiveness. The report is organized in terms of these, and other, issues.

Intent of This Report

This report identifies ways that the production of knowledge through research can lead to better management of fire incidents. Fire management is an activity with many facets. This report is directed toward activities that are inherently managerial in nature and that involve management decisionmaking. By "better management" we mean management decisions that reflect a better analysis and accounting of those factors that are impacted by the occurrence of fire on public (and private) lands, including planning, operations, costs, safety, and rehabilitation. In the current social climate, fire management has come under critical review by federal organizations outside of the agencies specifically responsible for land management, and even by organizations outside of the public realm. Identifying approaches for better management of fire incidents can mean examining a wide range of perspectives on how fire management should be done, and reviewing our current fire management policies and practices with an eye to how those outside of the federal realm might interpret and respond to them. The limited scope of this report prohibits us from adopting this goal as a specific intent, but future research activities could at least consider the relevance of this broader view and address it where possible.

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There are several ways that the research community can respond to the needs we identify. One way is through the planning and execution of research that focuses on the development of new methods and tools that can be applied by the fire management community. A second approach is through a process whereby the results of existing research are "translated" to meet the needs of fire management. Translatable research is potentially available from the federal research community (e.g., USDA Forest Service research stations) and from the broader academic and nonacademic research world (e.g., universities, other research laboratories). The latter repository of research may be particularly valuable in addressing issues relating to risk assessment and risk management, discussed later in this paper. A third approach is to focus research on the development of training and education programs that provide an integration of research scientists and field managers through consultations, workshops, and Web-based education products.

Throughout this report, there are references to fire managers and the fire management community. Fire management is not the domain of a single set of professionals, and fire incidents of the type that engender the concerns motivating this report engage a broad range of management staff, including unit administrators or line officers (e.g., forest supervisors, district rangers), fire staff (e.g., fire management officers), incident management team members (e.g., incident commanders), and resource area specialists (e.g., biologists, hydrologists). Our focus is on management and management decisionmaking; at different times and in different ways, all of these individuals may participate in the management decisionmaking surrounding an incident. The skills, training, education, and tools that they bring to the management of fire are part of the larger decision process that determines how a given incident will be approached and what its final outcome(s) will be. The research opportunities identified in this report apply to all levels of management and management-related expertise that are brought to bear on the management of fire.

The Challenge of Integrating Research and Operations

There have been many calls for research to address the needs of field operations, including the needs of fire management. We echo those calls here, but offer as well some insights on the challenges that both the research and field communities face as they pursue seemingly common goals. Some of these challenges occur because of their physical separation–fire management activities take place in real time in response to emergency events that occur over a dispersed geography, whereas research activities occur over long timespans in a highly localized geography. This is not to say that researchers and fire management personnel cannot "work together" but that working together in a close and collegial way requires institutional structures that allow for more rapid involvement of researchers in fire management incidents than is (generally) currently the case. Arrangements need to be in place for research personnel to be part of operational activities. Conversely, fire management organizations may need better guidance on how research personnel can better support the goals and objectives of the fire management community.

A second challenge arises from the very different nature of the incentive structures that operate in the research community versus the fire management community. Research personnel operate within a scientific framework where accomplishments are measured in terms of highly individual, scientific outcomes often with a scholarly focus. The values of the research community reflect long-term achievements that may require years to produce, but that rest on a solid ground of scientific methodology. Fire management personnel operate within a framework of events seldom under their direct control, where accomplishments are measured in terms of short-term outcomes, such as protection, cost containment, and organizational integrity. The values of the fire management community reflect day-to-day performance and an ability to work with others in a highly turbulent decisionmaking context. Melding these two cultures requires a mutual recognition of the values that guide each, but, moreover, requires a synchronization of efforts based on a continuous, ongoing identification of needs, actions, and outcomes. One approach for achieving this goal is to develop "intermediaries" who can translate field-related issues and questions into research hypotheses, and can translate research results into field-relevant applications.

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The Concept of "Tools"

Much of the recent work at the science-management interface has included a strong focus on developing tools useful to managers. This has especially been the case in the fire community where research outputs are highly valued when they can be described as tools that can be placed in managers' hands. This raises questions about the definition of tools.

Very often we look upon tools as substantive, physical devices that have the essential property of providing assistance or support for accomplishing a particular job or task. In the modern idiom of technology and science-based management, tools often take the form of software or other computer-based applications. "Decision support," for example, very often means tool-type aids embodied as computer programs that provide one or more functions such as information integration, problem structuring, analysis, and document formatting.

We propose that such a definition of tools is too restrictive and, indeed, may do a disservice to both research and field operations by limiting the range of opportunities for mutual and constructive interaction. The concept of "tools" can be extended to include not only computer software but also other forms of checklists, inventories, guidelines, and templates based on research and that can serve the needs of fire management. If we extend the concept of tools to include "means" of various types to achieve one or more "ends," then we can include field-related outputs of research such as consultations, workshops, seminars, and other forms of training and education, as forms of "tools" to support fire management operations.

Defining Tools for Cost Containment

Cost containment with respect to wildland-fire suppression has become one of the dominant issues confronting fire management today. In addition to the various national-level reviews that have touched on the need and potential methods for improving cost containment, virtually all post hoc fire reviews (single incidents and complexes as well) address cost containment in some form.

This report provides an overview of the issues associated with cost containment and tries to distill the results of the many reviews that have been done on this topic. Moreover, as our backgrounds are in the areas of decision, risk, and management sciences, and not in cost accounting, we approach this topic from the perspective of those disciplines and from the perspective of our field experiences where matters of cost are part of strategic planning and decisionmaking.

The Meaning of Cost Containment

Although the concept of "cost containment" is used throughout the fire management community today, it is seldom given a precise definition. Most commonly, managers consider "containment" as keeping within some predefined bounds. Thus, cost containment implies the notion of a budget, limitation, or benchmark on fire suppression spending. Given this definition of cost containment, the research questions become something akin to: What benchmarks or guidelines constitute cost containment? What rate of growth in fire suppression costs is acceptable and how should or could acceptability be gauged? How should or could historical costs be used as a basis for cost containment guidelines? In essence, cost containment becomes a **prescriptive** concept where the cost outcomes of a fire suppression action can be compared with a budgetary framework to gauge the quality of fire management with respect to cost. At present, many of the fire reviews tend to approach cost containment in terms of "cost efficiency," that is, whether the same suppression activity (presumably with the same effectiveness) could have been obtained at a lower cost. However, the two concepts, cost containment and cost efficiency, are not the same.

A second definition for cost containment views it as a process: What measures or steps are (or should be) taken by fire managers to keep the costs of fire suppression as low as possible without significantly compromising fire management objectives? By this definition, many activities can serve the objective of cost containment, including research activities.

The distinction between an outcome and a process definition of cost containment would border on academic were it not for the repeated observation in the field that the lack of a consistent and clear definition for cost containment is sometimes a source of confusion, and it is not clear what measure or guidelines are consistent with cost-containment principles. In addition, fire managers may be confused as to whether or not their decisions are adequately incorporating the principles of cost containment, or how they could even tell whether such is the case.

As a case in point, consider that within a WFSA, the setting of strategic direction for fire management involves the development of expected suppression costs for each alternative evaluated. Within the WFSA analytical framework, the comparison of multiple strategies is done with respect to cost efficiency: whatever errors or biases exist in cost estimates operate equally across all strategic alternatives in the analysis, and it is the **ratios** of costs that are important (and appropriate to consider), not the absolute level of costs. In recent years, however, the cost estimates within WFSA have been taken to reflect cost predictions and the "most cost efficient" decision rule that has historically guided the selection of a strategic alternative has been replaced with a "least-cost" decision rule.[1] Yet, the WFSA framework does not provide the necessary analytical model for making such predictions. The two tools within WFSA for estimating expected suppression costs are (a) average acre costs based on interagency initial attack assessment data for the unit under analysis, and (b) a cost estimate based on a user-generated inventory of suppression resources (and their costs) that might be required for a suppression action. For field users of WFSA, the cost containment question is one of whether these tools and their use constitute meeting the goal of cost containment. If a fire manager suppresses a fire at a cost consistent with the per-acre costs in WFSA, has cost containment for that incident been achived?

Cost Containment and Values at Risk

Fires are fought to protect values judged to be at risk. To the degree that the value of those things at risk can (with fidelity) be represented in terms of monetary values, then they can be compared directly with suppression costs to determine the degree to which the expenditure of suppression resources constitutes a reasonable cost. Within the historical framework of suppression cost efficiency supported by the National Fire Management Analysis System, such comparisons can be made and the adequacy of cost containment more readily assessed. However, the predominant values at risk in today's fire incidents are not commodified federal resources (e.g., merchantable timber, grazing), but private resources (e.g., homes, communities)

[1] The cost efficiency concept embodied within WFSA reflects its orientation toward a commodification of resource values based on National Fire Management Analysis System. A detailed review of the effects of this orientation on decision rules within WFSA is beyond the scope of this paper. For a more indepth discussion of this point, see MacGregor 2002a.

that have values noncommensurable with the monetary costs of fire suppression. Very often suppression costs are incurred to protect private structures that exceed the structures market (monetary) value.

The tools we have today for fire management decisionmaking take very poor account of this noncommensurability, making it difficult with even the most thoughtful planning to directly assess whether a given (planned) suppression action is "worth" its costs. This is a problem not only for suppression of wildland fire but also for development and implementation of fuel management programs where the value or benefit of wildland fire threat reduction must be measured (in part) against the costs of such programs. There is an opportunity for research to provide information that will lead to better guidelines or strategies for comparing costs with values at risk when the two are noncommensurable, and for identifying appropriate measures or procedures for "cost containment" when noncommodity values are threatened by wildland fire.

Although policies and directives provide guidance to individual fire managers about the goals and objectives of the organization as a whole, a fairly wide latitude is available for individual interpretation.

The Role of Incentives in Cost Containment

Wildland-fire suppression costs are the result of decisions made with respect to strategies and tactics that have as their outcome the protection of values at risk, or the attainment of resource benefits. Decisions are not made by systems and tools, they are made by people, and result from a combination of social, organizational, and personal values. Some of these values reflect preferences and perspectives on risk of individual managers, including the implication of decision outcomes for their individual well-being and future within the fire management community. Although policies and directives provide guidance to individual fire managers about the goals and objectives of the organization as a whole, a fairly wide latitude is available for individual interpretation.

A 2003 report titled *Large Fire Cost Reduction Action Plan*, by senior managers from the U.S. Department of Agriculture, U.S. Department of the Interior, and National Association of State Foresters (USDA et al. 2003) noted the following:

> Our culture and incentive system are not oriented toward reducing the costs of large fires. Currently, the local Agency Line Officer and Incident Commander have three primary objectives: (1) ensure firefighter and public safety; (2) suppress the wildland fire; (3) respond to community needs.
>
> Unfortunately, any incentive to reduce costs is absent from these three central responsibilities. At this time, there is more incentive to reduce risk rather than reduce costs. We must change this. Beginning this fire season, we must elevate cost containment commensurate with other objectives.

To truly accomplish this, we must also be able to alleviate our managers' concern regarding personal risk. Not risk in the personal liability sense, but more akin to a career altering/ending event. At the same time, we must also reward our managers who exhibit and make good progress in cost containment.

For cost containment to succeed (either as an outcome or as a process) requires an incentive structure that offers clear rewards to managers who make decisions with cost containment as an objective and an outcome.

The observation of this team is a salient one. For cost containment to succeed (either as an outcome or as a process) requires an incentive structure that offers clear rewards to managers who make decisions with cost containment as an objective and an outcome.

Fire management on the ground is very much a command-and-control exercise, and a great deal of fire management decisionmaking is done by key individuals who occupy roles or assignments that have command authority. It is tempting to think that organizational decision processes (including policies and directives) provide a sufficient basis for accounting for the actions of individual decisionmakers. In reality, individual preferences, attitudes, and perceptions of risk can overshadow organizational incentives for decisionmakers to act in known (or knowable) ways. To date, we have very little (if any) research on how various organizational policies, decision problem structures, directives and the like interact with the incentive structure of individual decisionmakers. Such knowledge is essential if we are to understand better why, for example, fire incidents cost what they do. Important research questions here include:

- What are the incentive structures of fire management decisionmakers?
- How can individual incentive structures be characterized in terms of decision-related concepts, such as risk and uncertainty?
- How do characteristics of key, fire-related organization policies relate to individual incentive structures?
- How do individual incentive structures influence incident decisions, particularly incident decisions that impact fire costs and firefighter safety?
- How can organization policies and directives take better account of individual incentive structures?

Typology of Fire Management Situations

Fire is a complex phenomenon. To describe it succinctly and completely is an enormous challenge. As an initial starting point, consider a typology of wildland

[2] A more complete treatment and development of this taxonomic framework would include wildland fire use. The more limited framework of suppression does, however, provide some convenient starting points that help define the form such a taxonomy might take.

fire management from the perspective of fire suppression.[2] We can describe fires in a number of ways, some of which have become part of the cultural context within which fire management evolves. Perhaps the least complex way of describing a fire incident is in terms of its physical and temporal parameters: size, location, time of year, duration of incident, time to control, time to contain, etc. A slightly more sophisticated description might be in terms of the behavior or features of the fire itself: fuel types involved, flame lengths, crown fire activity, etc. A fire can also be described in terms of environmental factors, such as weather, winds, humidity, fuel moistures, and other indices or metrics that provide in one way or another a partial accounting of the causes for the extremity of the incident.

Fire descriptors take on social properties when fire is described in terms of economic factors, such as values at risk or lost owing to the fire (e.g., species, habitat, recreational structures, private homes). In this category of descriptors is included the monetary cost of fire suppression, one of the more salient descriptors for large-fire incidents.

We get closer to human factors as descriptors when we begin to describe a fire in terms of who was involved, how many people worked on the fire, the particular incident commanders or incident management team associated with the fire, and the like. Injury and mortality events among fire suppression personnel also contribute a human element to fire descriptions.

However, one category of descriptors that is rarely used to characterize fires is that related to decisionmaking and particularly to decisionmaking associated with management.[3] The problem with the more common descriptors is that they may be of limited use (at best) in improving understanding of how and why a particular set of fire outcomes occurs in terms of managerial decisionmaking. As a result, we are often left without an adequate description of costs that identify how featural elements of an incident combine with other factors outside of the incident itself (e.g., social values, organizational policies) to influence incident decisions and outcomes. A general model that indicates the decisionmaking stages of a large-fire incident is shown in figure 1.

This model illustrates the basic units of decisionmaking in the context of a fire incident. Each unit is placed along a timeline that defines the beginning of the incident to its formal ending. The formal ending of an incident is defined as the time and date the fire is considered out and reported as suppressed. Other ways of

[3] Perhaps the only exception to this is the WFSA that is itself a decision-support process and, therefore, characterizes the fire in terms of decision elements.

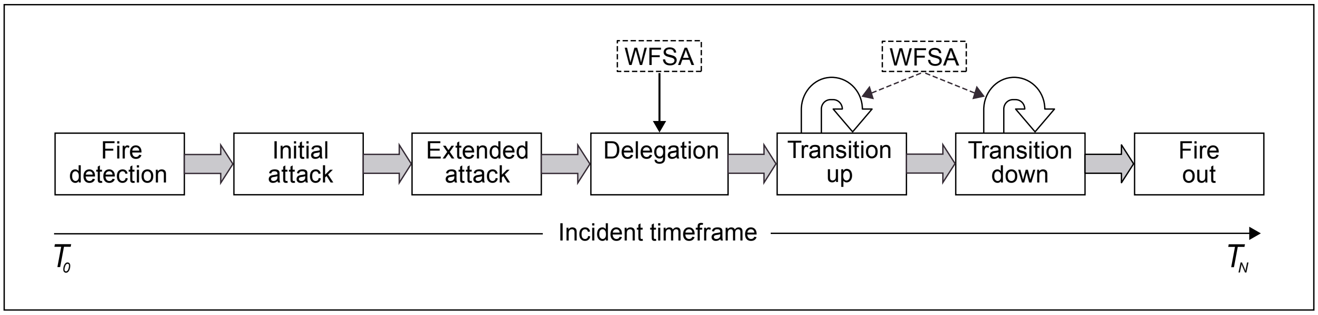

Figure 1—A general model of the decisionmaking stages in a fire incident.

defining decision process stages are possible. This particular description is offered to indicate the general principles of the analysis framework to follow. We acknowledge each box might include multiple sets of decisionmakers such as the case where there are incident command transitions.

Although the various decision process stages shown in figure 1 are placed along what appears to be a linear time dimension, in fact, most managerial decisionmaking is highly skewed to the left (nearer the beginning of the fire). Large-fire incidents generally escalate relatively quickly, and the time from fire detection to delegation of authority to an incident team may be only a matter of days or even hours under some circumstances. For long-running (or siege fires), the timeframe may become particularly extended during the transition stages. For most long-running fires, the step associated with transitioning down to a final determination that a fire is out may be extended for a considerable period. During this period, some resources may remain attached to an incident, and continuous monitoring may take place. The circumstances that determine a fire being declared completely suppressed (and the incident concluded) have not yet been modeled.

Siege Fires

Fires become costly, in part, because of factors that influence the timespan over which an incident continues. In these cases, a fire management effort may extend over a number of days, and perhaps as long as 2 weeks or more (until a fire-ending weather event occurs). Under some circumstances, however, a fire may extend into several weeks and even months. These incidents become “siege fires,” in which a combination of national priorities, environmental conditions, and social factors (including human resource factors) combine to produce a long-running fire that can become extremely costly because of the timespan involved. Several factors appear to characterize the phenomenon of siege fires.

Siege fires grow in at least two dimensions: (a) physical size and (b) temporal frame, but also require an increase in fire management personnel to manage or suppress the fire. For most fires, physical size and temporal frame are highly correlated: the longer a fire continues, the greater the geographic area involved. However, some very long-running fires, may last for some time either without expanding in area or while expanding only slowly in area. Indeed, for virtually all fires large enough to warrant local delegation of authority to an outside incident management team, management activity on the fire may extend well beyond the timeframe for its physical growth.

Concomitant with fire growth in physical size is growth in terms of organizational size. Larger fires demand greater managerial resources and, in many cases, lead to greater managerial complexity. Although we do not yet have sufficient research data to draw conclusions, it is conceivable that in some cases, siege fires reflect an inherent inefficiency in the management model applied to the fires. The economy of scale expected from larger management organizations may not be realized, with a resulting marginal decrease in managerial productivity as the fire management organization grows in size. Lack of managerial coordination, limited managerial experience, and communication difficulties all may contribute to this effect. Although at present we have methods for identifying the **advised** level of managerial expertise required to manage an incident, we do not have a method for characterizing or describing the managerial complexity of a fire incident from the perspective of decision processes.[4] An appropriate method would, at least in part, consider the particular management challenges presented by an incident and would relate those challenges to decision processes required to meet incident objectives.

We can also examine the siege-fire phenomenon from the perspective of the interaction between physical size of fire incidents and their temporal frame. Figure 2 shows a simplified two-by-two description of physical size (small vs. large) versus temporal frame (long vs. short). Within each of the four cells are shown some characteristics of fires that populate these interactions.

Fires of small physical size and a short timeframe represent the majority of fires that occur. Historically, this has been the most desirable condition (and outcome) and is reflected in the agency's policies toward initial attack and aggressive posture with respect to fire suppression. Fires in this category have generally been economically efficient from the perspective of resource loss, particularly for commodity resources (e.g., timber). Organizationally and managerially, effective suppression of these fires in initial attack leads to a highly success-oriented fire suppression

[4] An incident complexity analysis is a required step in determining the appropriate managerial response to a wildland fire incident. The incident complexity analysis is usually done as part of the WFSA to determine the type of incident management team required: type I, II, III, or IV.

Temporal frame		Physical size: Small	Physical size: Large
	Short	• Ideal fire, historically desired situation and outcome. • Quick decision tempo. • Tight action-outcome links. • Success oriented. • Economically efficient.	• Unusual fire, probably at end of season. • Relatively costly. • Potential source of concern. • Perhaps high values at risk. Costs relatively justifiable.
	Long	• Relatively isolated fire. Low priority. • Few values at risk. • Constant monitoring, potentially high cost.	• "Siege" fire. • Extensive suppression resources fielded. • Potentially very high cost. • Disrupted decision tempo.

Figure 2—Characteristics of fire incidents by physical size and timeframe.

culture. From a decision-process perspective, these fires have very tight action-outcome links and a fast-paced decision tempo (MacGregor 1993). That is, the managerial pace of the fire is high, decisionmaking is more intuitive and less deliberative, and positive (effective) outcomes are quickly realized. Fires in this category represent the majority of the cases in which fire management experience is gained, largely because such fires represent well over 90 percent of all fires.

A small fire can continue for a long time if it is relatively isolated with few values at risk. Costs can be incurred if the fire requires constant monitoring. These fires are relatively rare and are generally limited to specific geographic regions. Fires of large physical size can have a relatively short timeframe, particularly if the fire occurs near the end of a fire season when fuels are dry but a season-ending weather event is near. These fires can be relatively costly, particularly if they occur in a wildland-urban interface area.

Large fires that burn over a long timeframe occur relatively rarely, but draw a high level of concern. Fires in this category may be classified as "siege fires." In general, they result in very large suppression costs, require a high level of management expertise, and may undergo a number of incident management team transitions. Many of these costs result from scaling-up where resources are added in direct proportion to the growth in fire size. Numerous sociopolitical issues may be involved. In addition, the fire may span multiple jurisdictions (including federal, state, local, and private). Decision processes for these fires can become quite complex owing to (a) numerous values at risk, (b) multiple team transitions, (c) relative ineffectiveness of suppression resources, (d) competing land management objectives across jurisdictions involved, and (e) "atmosphere of defeat" as the incident extends beyond the usual timeframe within which the fire organization typically achieves success. Fires in this category also tend to draw a relatively high level of managerial oversight within the affected agencies, as well as oversight from other agencies and organizations that are impacted by the incident. These factors can contribute to the overall level of stress on managers and increase the complexity of decisionmaking through the addition of sociopolitical concerns that may compete with economic efficiency.

Research Issues and Opportunities

These issues represent opportunities for research directed toward understanding better the nature of fire management decisionmaking in fires of various types. As a starting point for such research we conceptualize a fourfold typology of fire management:

- Initial attack fires
- Extended attack fires
- Incident management team fires (e.g., delegation of authority to a different incident management team every 14 days)
- "Siege" fires (e.g., high degree of mobilization, multiple management team transitions, and potentially large cost)

This typology is based on current procedures and guidelines for upward mobilization of incident command as a fire grows in size and/or physical complexity. Among the important research questions in this realm are:

- What problems and challenges are faced by fire management in decision-making for each fire type?
- How are decision problems structured within each fire type?
- How is the structuring of decision problems influenced by organizational factors, such as professional specialty (e.g., land management vs. fire management; stewardship vs. protection)?
- As fires move from one "type" to another, how does the decision problem structuring change? Are there inconsistencies that influence quality of decisionmaking?
- What are the relationships between decision elements (e.g., values at risk, range of consequences, uncertainties, strategic options) and fire costs for each fire type?
- What processes or structures can be developed to improve the quality of fire management decisionmaking within each fire type?

Decision Problem Structuring of Fire Incidents

A critical feature of decisionmaking at each of the stages shown in figure 1 is the form and extent of problem structuring that is available or provided, and the demands imposed on fire management personnel to provide their own problem structuring or to augment the problem structuring that is given. A complete analysis of this issue is beyond the scope of this paper, but some salient examples will be given to illustrate the concept.

Problem structuring in this context refers to the framework or guidance given to a decisionmaker with respect to a decision problem. For example, at the "Delegation" stage of figure 1, a local unit administrator must decide the "best" strategy to pursue with respect to managing an escaped fire, and identify the relevant level of incident management expertise required to implement that strategy. The definition of "best" in any given incident context will depend on land managers' perceptions of relative landscape values threatened by the fire and related suppression activities. In principle, these perceptions should be based on the values contained in the land management plan (LMP) for the administrative unit. In practice, the LMP may require translation and interpretation to put landscape values in a form that can be used by subsequent analysis processes such as WFSA. The WFSA is a decision process set in place by USDA Forest Service policy to support a unit administrator in making a decision regarding the best fire management strategy to pursue. The WFSA provides a problem structure by which the decision can be analyzed in terms of (a) land management values at risk, (b) alternative suppression strategies that could be implemented, (c) the impact of each strategy on values at risk, and (d) costs of suppression. The WFSA structures the problem according to a framework based on decision analysis and multiattribute utility theory but requires of the user (analyst) information, values, and judgments that themselves require structuring separate from the structuring provided by the WFSA. As an example, probability assessments are required by the WFSA problem structure, but no structure is given to support the development of such assessments.

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As a second example, consider the incident complexity analysis that is part of the delegation process. The incident complexity analysis takes the form of a checklist containing a number of elements relating to fire behavior, resources committed, and resources threatened. Each element is "checked" according to whether it is present (or not) in the incident. Guidelines are given as a judgmental aid for determining the type of management expertise required. Problem structuring occurs with respect to a set of factors relevant to the determination of incident complexity. Less structuring is provided with respect to how the various factors should be combined to reach an overall determination of incident complexity.

Problem structuring is critical in accounting for decisions on fire incidents in part because the level and type of problem structuring provided determine the potential effect of outside influences on decision processes. Framing effects can be induced by the particular form or structure that a decision problem takes (e.g., gains vs. losses; checklist vs. calculation), or can be imposed on a decision problem by the pre-existing preferences of a decisionmaker (e.g., risk attitudes; career experiences).

Problem structuring is critical in accounting for decisions on fire incidents in part because the level and type of problem structuring provided determine the potential effect of outside influences on decision processes.

Stewardship Vs. Protection as Problem Structures

Conflict in problem structuring occurs because various managers in the fire management area have potentially conflicting problem definitions. This is apparent in the case of unit administrators, such as forest supervisors, and those professional specialties that deal more directly with fire suppression, such as fire management officers and incident commanders. Unit administrators primarily occupy a **stewardship** role in land management: their charge is to manage a set of resources to achieve a set of desired future conditions based on a long-term planning process. Policy and other planning directives frame fire management problems in terms of both threats and opportunities: threats to near-term resource values at risk, and opportunities to return fire (as a benefit) to the ecosystem as part of their overall stewardship mission. Fire-suppression managers largely occupy a protectionist role: their charge is to limit the damage done by fire (usually through suppression) consistent with protecting public and firefighter safety. Although there is some compatibility between these two perspectives, they do not overlap. For example, from a protectionist framing, outcomes in terms of acres burned reflect a short-term orientation toward evaluating the quality of a fire management action. However, from a stewardship perspective, acres burned may reflect a more positive (or less negative) outcome in light of the degree to which other stewardship goals are met (e.g., noxious weed reduction; improved habitat). These alternative perspectives may pose difficulties for setting well-grounded and consistent strategic direction for wildland fire management, particularly in situations where communication of stewardship objectives is incomplete or untimely with respect to influencing strategic direction for fire suppression, as may be the case in larger fires where management authority is delegated outside the local unit.

Tool Use in Wildland Fire Management

Over the past two decades, the challenges and problems of wildland fire management have grown enormously in response to a greater need to protect both public and private resources from the devastating effects of wildland fire. One indication of this response is the ever-increasing development of analytical models and tools, many of them computer-based, to aid and support various aspects of wildland fire management, including fire planning and budgeting, fire economics including financial analysis, and the analysis of fire behavior. In addition, as advances in computer technologies have put greater computational sophistication in the hands of more wildland fire management personnel, older tools that once were available only on large computers have been adapted to personal computer platforms and even to hand-held, highly transportable computer devices. With these rapid changes in technology has also come a broader range of computer-based tools developed not only by federal fire-management agencies but also by state agencies, universities, and the private sector.

A recent trend in models and applications for wildland fire management has been the integration of stand-alone programs into frameworks or suites. These integrated applications may include a combination of older applications known by their separate names, as well as new applications developed and included for additional functionality.

A recent inventory of computer-based tools for use in fire management identified over 70 applications that have been developed to the stage of implementation (MacGregor 2002b). A more complete review would show that the emphasis on tool development has been based on modeling the "environment" in which fire management occurs (e.g., fire behavior, fuels, fire effects), but relatively little emphasis has been placed on modeling the **management** side of the fire management equation. With the notable exception of the WFSA (discussed in greater detail below), most of the tools developed to date do relatively little to model the management problem from a decisionmaking perspective.

A particular challenge for computer-based fire management tools is posed by the diversity of conditions under which they are developed and maintained. The existing models and applications used in the field have become established over a number of years through patterns of use. There is a lack of consistency in terms of either the process of their development or the management of their upgrading and documentation. The different development and management approaches have led to inconsistent processes and products, and at the same time there are gaps with respect to the needs in the field for tools that provide support for fire management decisionmaking.

There has been no systematic study of how these models are being used (if they are), by whom, and under what circumstances. Furthermore, we have no research that identifies what role or effect the majority of these models are having on wildland fire management processes and activities. Focused research is needed to better understand the role that (at least some of) the more well-known models (e.g., Fire Behavior Prediction [BEHAVE], Rare Event Risk Assessment Process [RERAP], Fire Area Simulator [FARSITE]) are playing in the management of wildland fire. The scope of such an effort could be made more reasonable by initially studying a small set of models as an approach for establishing patterns of use of the more popular ones. The results of such a study would provide a more complete definition of wildland fire management with respect to the technologies that have been developed to support it. In addition, the results would also show weaknesses in current technology-transfer efforts and help identify ways to improve technology transfer.

The current fire-review process does not undertake a review of the tools used in fire management decision support, with the possible exception of the WFSA. Wildland fires could be studied (as part of review) to determine what models were used as part of the incident and how they were applied.

Wildland Fire Situation Analysis

One of the most widely used tools in fire management is the WFSA. The WFSA is essentially a decision-support process that provides an analytical method for evaluating alternative suppression strategies, represented in terms of their goals and objectives, suppression costs, and impacts on the land management base. In addition, it forms the basis for a rationale and description of a suppression strategy that is contained in a delegation of authority, communicated from a unit administrator to an incoming incident commander.

The general form of WFSA is embodied in the USDA Forest Service Manual (5131) in the form of analytical requirements or "steps," which accounts in large part for the frequency of its use. In essence, the policy identifies three distinct analytical requirements that call on the agency administrator to:

- Identify criteria for evaluating suppression alternatives.
- Develop suppression alternatives.
- Analyze suppression alternatives by using the evaluation criteria, and select the alternative that "best provides for firefighter and public safety, minimizes the sum of suppression costs and resource damages, and has an acceptable expected probability of success or failure."

The WFSA can be viewed as a method of prioritizing or evaluating decision alternatives according to each of three approaches: (a) how well each decision alternative meets a set of land and fire management objectives, (b) the suppression costs of implementing each alternative, and (c) the economic impact of each alternative (if implemented) on the natural resource base.

Over the years of its implementation, WFSA has drawn much scrutiny and review, some of it highly critical. In post hoc fire reviews, WFSA is very often discussed in terms of difficulties or challenges either posed to WFSA or brought about by WFSA.

A 2002 study by the National Academy of Public Administration of fire management decisionmaking with respect to cost control examined, among many aspects of fire management, the role and potential for WFSA to exercise and support cost control (MacGregor 2002a). The review of WFSA identified a number of possible opportunities for improvements to WFSA that have the potential to influence cost control. These included:

- Improve WFSA user training and education.
- Develop standards for WFSA qualification and certification.
- Integrate WFSA with fire management and land management planning.
- Integrate WFSA with other decision-support tools and processes, and with cost-relevant databases and models.
- Clarify guidelines for negotiation and adoption of delegation of authority based on WFSA.
- Expand research on WFSA, including research on its role in fire management decisionmaking.

Efforts have been undertaken to implement some of these recommendations, at least in part: WFSA training workshops have been supported at the national level, cost-review “trigger” points were established for the 2003 fire year, and some discussions have taken place regarding a WFSA proficiency standard. For the most part, however, these recommendations still stand as fruitful directions that could be pursued by research if done jointly with field cooperation.

A second set of WFSA challenges and recommendations comes from the individual post hoc fire reviews, two of which were attended by the authors of this paper. The WFSA issues that emerged from these reviews follow:

Representing Values in Wildland Fire Situation Analysis

Land managers assert that they are protecting high-value resources. However, it is difficult within the WFSA process to define clearly and consistently the values protected and their worth, particularly when placed against the costs of fire suppression. At present, many of the value representations within WFSA are highly subjective. The WFSA process itself gives little or no guidance on how such subjective judgments of value should be formulated and documented. There is an opportunity to develop better methods for identifying the values protected in fire actions (and represented within WFSA) in ways that can be compared with the costs of fire suppression.

Wildland Fire Situation Analysis and Incident Complexes

The WFSA is sometimes seen as an incident-driven process that has difficulty representing fire management decisions that span multiple incidents or "complexes." The essential structure of WFSA is capable of dealing with incident complexes as well as incidents made complex by the involvement of multiple jurisdictions. However, extending WFSA to these classes of situations could be improved with refinements to the process (and the software) as well as enhancements to training. The issue of the relevance of the current WFSA process to more complex fire situations is one of problem structuring: WFSA as it is today is most suitable from a problem-structuring perspective for single incidents involving a single jurisdiction. A more flexible or broader WFSA could be developed that would use a checklist to identify the features of a fire management situation, and then structure the WFSA problem accordingly.

Estimating Suppression Costs in Wildland Fire Situation Analysis

The WFSA is, as currently fielded, a tool that analyzes the relative cost efficiency of strategic alternatives for managing a wildland fire. The cost-efficiency comparison in WFSA is based on cost estimates made by the WFSA analyst. Within the WFSA software, some tools are provided to support these estimates. When properly configured, the WFSA software provides average-acre suppression costs (based on historical interagency initial attack assessment data), and a set of menu-driven prompts that help the analyst select suppression resources from a list that is then aggregated and reflected in a total cost for each alternative in the analysis. The analyst has available the ability to modify and/or reconcile estimates made by alternative means. However, these estimates are still very much a matter of expert judgment and evaluation of suppression alternatives. Historical suppression costs need to be modified based on expert judgement to, e.g., (a) bring them into line with likely current costs based on inflation rates, (b) account for other cost factors that may not have been included in historical figures, and (c) match the current fire under analysis with fires upon which the historical cost figures were based. The WFSA provides no help or support for making these judgmental corrections and instead adjusts to historical fire costs. User-developed suppression cost estimates are entirely dependent on the judgment of the individual WFSA analyst and his/her experience with escaped fires. Alhough no research is available on what biases might exist in these judgments, experiences from WFSA training sessions suggests that cost estimates in WFSA may be too conservative when compared with actual costs. There are opportunities to develop better models of cost prediction that can be incorporated into WFSA. For example, regression models for predicting costs, based on features of incidents and that incorporate a larger number of factors than is currently the case in WFSA, may be helpful in this regard.

Fire Planning and Incident Simulation

Land management today on federal lands involves a matrix of planning efforts and analyses, including LMPs, fire management plans (FMPs), watershed analyses, and planning for late successional reserves. In principle, these various planning efforts should work together to support management decisionmaking on a given fire incident. In practice, our observations are that this is not the case. What we have is a set of somewhat discontinuous planning efforts, each of which is relevant to a specific aspect of land management issues, but which generally have been done without regard to strategic planning for fire. Sometimes plans are outdated, as is the case for a number of LMPs. In other cases, the planning concept may be unclear or unevenly applied, such as appears to be the case for FMPs. Three issues that appear to emerge repeatedly with respect to planning efforts and fire management are (a) the integration of land management and fire management planning, (b) the meaning of "strategy" as applied to fire management, and (c) the need for "gaming"[5] approaches to train individuals for future fire incidents.

Research needs to be directed toward understanding how the land and fire management planning processes can be better integrated and subsequently translated in terms that can be applied via current fire management tools such as WFSA.

Integration of Land Management and Fire Management Planning

One way to think of WFSA is as an extension of the LMP and FMP to the context of a specific incident. Whether we call the process by which we do this "WFSA" or call it something else, the management problem in using LMP and FMP as a basis for decisionmaking on specific fire incidents is one of translating their guidance into meaningful direction that is consistent with these "upstream" planning efforts. This is an enormous challenge and one that is too-rarely done with a sufficient degree of analytic depth to ground incident-based fire management decisions within a planning context. Research needs to be directed toward understanding how the land and fire management planning processes can be better integrated and subsequently translated in terms that can be applied via current fire management tools such as WFSA. In addition, planning activities need to take account of cost-containment principles in plan development.

[5] Gaming approaches frequently involve computer-based simulators that help managers assess fire risks and the effectiveness of different suppression activities to manage those risks and associated fire situations.

The Meaning of "Strategy"

The concept of strategic decisionmaking is central to achieving the goals of fire management (and cost containment). And yet, the definition of strategy in a given incident context often becomes confused and misapplied. In principle, strategy refers to an overarching plan or direction, the focus of which is objectives or the "ends" that are desirable (or acceptable) to achieve. The "means" for achieving those objectives are generally methods and "tactics." However, one person's tactics can be another person's strategy, as is the case in fire management where shifts in decisionmaking from (e.g.) forest supervisor to FMO to crew boss can affect how strategies and tactics are defined and applied. The problem is serious because at each of these management levels, the objectives change: e.g., land managers are primarily concerned with stewardship and must take management account of a broad range of resource objectives (e.g., timber, habitat, recreation, air and water quality); fire management staff have other objectives that are primarily related to protection, fire behavior, and fire effects (e.g., firefighter safety, crew management).

Decision Structures for Future Fires

A principal means by which management decisions can be improved is through the use of gaming and simulation exercises to model both the context of a specific management problem (e.g., fire behavior, values at risk) as well as the managerial response (e.g., evaluation of strategic alternatives). At present, some capabilities exist within the fire management community for such activities. However, at the unit level (e.g., forest, district), very little (if any) tools and expertise are available for organizing and implementing such exercises. Fire management staffs discuss fire but largely in terms of historical incidents. Prospective discussion of fire is generally in terms of pre-positioning of fire suppression resources. Strategic gaming of incidents that are specific to a management unit does not have a consistent framework, nor are guidelines available and tools developed to assist with such exercises. Research can be directed toward the development of methods and tools that local units can use to support the conduct of simulations of potential incidents that would pose challenging management problems. Such tools should include the capability to give local land and fire management staff a grounding in cost containment principles.

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Risk Assessment in Wildland Fire Management

The field of risk assessment is a large one, and a complete review of its potential for fire management is beyond the scope of this paper. We introduce risk assessment here because fire management is inherently the management of risk, and it is risk to those things that are of value that motivates the protective actions of the

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fire management community. The concept of risk has many definitions, and a detailed overview of these definitions and their implication for the development of fire management tools needs to be undertaken. For the present, it is sufficient to adopt a definition of risk as (a) the set of events that can occur, (b) the likelihood of their occurrence, and (c) the outcomes or consequences associated with each.

The current tools in wildland management are relatively limited with respect to risk assessment. The WFSA has a very limited capability to represent the outcomes of a set of strategic alternatives in terms of their probabilities and consequences. However, the process itself relies on other processes (e.g., best and worst case analysis, scenario generation) to yield the necessary "inputs" to the software. The software provides no other support for risk assessment.

The RERAP model has the ability to provide probabilistic information with respect to the occurrence of a fire-season-ending weather event but does not fit well into a larger risk-assessment framework and is best thought of as a tool for providing a single (though potentially very relevant) piece of information. Fire modeling tools like FARSITE do an excellent job of characterizing fire behavior, and even the effect of suppression actions on fire behavior, but are not integrated with strategic analysis tools (like WFSA) to provide an analytical basis for assessing the impact of fire spread on land management objectives. In essence, risk assessment techniques are embodied in one way or another in many of the tools currently available to the fire management community, but they are not integrated into an overall risk assessment ensemble that fully integrates modeling of the fire environment with modeling of the management situation. Until this is accomplished, we will not have a sound basis for fire management based on risk assessment principles.

Risk Assessment Training and Education

As fire management organizations move to adopt risk assessment methods, a greater need will arise to ensure that managers receive the necessary training and education to implement these methods as part of their management practices. Systematic training efforts already underway will need to continually evolve to meet an ever-increasing need in the fire management community for a sound base of risk assessment and risk management skills. Historically, land management has focused on desired future conditions, with land management objectives identified in terms of fixed "targets." Risk assessment changes this orientation and conceptualizes the management context as one of a highly interrelated set of variables having a distribution of possible outcomes as the result of management actions. Risk management replaces well-defined, objective-based outcomes with sets of outcomes expressed in terms of uncertainty distributions. This poses a number of challenges to land and fire management, including (a) how best to develop management models for highly interrelated physical environments, (b) how to communicate risk assessment and risk management concepts **internally**, such as between managers and resource area specialists, (c) how to understand the meaning of managerial expertise in a context where outcomes are uncertain, and (d) how to communicate risk assessment and risk management practices **externally**, such as to those outside federal land management organizations (e.g., state and local organizations, special interest groups, general public and private organizations). Research can help address these issues by:

- Developing and implementing methods of training and education that provide the needed background in risk assessment.
- Developing management models and tools that incorporate the principles of risk assessment.
- Modifying existing fire management tools to better support risk assessment and risk management.

Management decisionmaking is a skill, and like all skills, it benefits from education and training, advice and consultation, and other forms of support such as information, research, and aids or tools.

Emergent Questions and Research Needs

Management decisionmaking is a skill, and like all skills, it benefits from education and training, advice and consultation, and other forms of support such as information, research, and aids or tools. It benefits also from experience, some in the form of actual on-the-ground incidents, and some in the form of repetition and exercise through games or simulations that pose difficult problems for which (sometimes-imperfect) solutions must be found. Fire management decisionmaking inherently involves judgment and decisionmaking under uncertainty. The classic (prescriptive) approach for dealing with problems of this type is a combination of analysis and synthesis: decompose decision problems into component parts, come to an understanding of those parts, and then reassemble the problem into a whole. In the context of fire management, this calls for a "well-analyzed fire management problem" (Rains 2000). Better analyzed fire management problems result in part from focused research on a number of fronts: research that addresses training and education needs, needs for advice and consultation, needs for science-based information and models, and needs for improved technical tools.

The problems faced by the fire management community today require that we improve the basis for analyzing fire management problems in terms of strategic decisionmaking and cost containment. This is, perhaps, the single issue to emerge most strongly from our participation in fire reviews as well as other research activities, and is the reason that the research questions identified in this report

The problems faced by the fire management community today require that we improve the basis for analyzing fire management problems in terms of strategic decisionmaking and cost containment.

are significant. We present here a synopsis of these separate issues in terms of research needs in the short and long term, and that provide support for the mission of fire management.

Short-Term Research Needs

Short-term research needs are those that can be addressed within the coming year or two. These are:

- **Integrate fire management and research as part of incident-review process**—Improved fire management decisionmaking will depend on the support of the research community through a process of integration. Research scientists need to be directly involved in fire reviews to identify research products that can be of value in extracting management recommendations from actual fire incidents. In the short term, this means, at a minimum, that research representation should be a part of fire management to the degree that time and resources permit.
- **Incorporate cost containment principles directly into fire management tools**—A number of reviews have identified cost containment as a critical issue in fire management. These principles need to be defined and research needs to be undertaken to understand how these principles can be directly incorporated into fire management decision processes. Initial effort could be placed on research to determine the feasibility of modifying the current WFSA process to achieve these goals.
- **Expand research on WFSA, particularly research on its role in fire management decisionmaking**—Here we echo a recommendation from the National Academy of Public Administration report on Wildland Fire Cost Control. The most pressing need is to provide a better ground for the establishment of strategic direction in wildland fire decisionmaking. The WFSA process is intended to fill that need. However, fire reviews and other research repeatedly identify WFSA shortcomings. Even if the WFSA were to be abandoned, some other process with similar intents would need to fill its place. At a minimum, in the short term, research should undertake to clarify the purpose of the WFSA process and what it is intended to achieve. At present, there is no consistent perspective on what (specifically) is desired from the WFSA process. If no consistency in perspective can be achieved, then a process should be designed that will serve the needs of fire management for a structured approach to setting strategic direction for fire management.

- **Develop a more transparent assessment of resources being protected to reveal land manager judgments and help frame the strategic context in fire decisionmaking.**
- **Develop new models of fire management relevant to a typology of fire management situations**—We need to develop more refined models of fire management decisionmaking at all levels of management complexity: initial attack, extended attack, incident management team fires, and very large or "siege fires." Research should address questions relating to the structure of decision problems within each fire type, as well as methods and processes for supporting decisionmaking.

Long-Term Research Needs

Long-term research needs are those that will require a timeframe of 2 to 4 years.

- **Conduct research to understand how current fire management tools are actually being used in fire management decisionmaking**—At present, we know much more about what tools have been developed than we know about how tools are actually being used in fire management decisionmaking. The principal tool in fire management for setting strategic direction is WFSA. Other tools relevant to this objective (e.g., RERAP, FARSITE) are available to the fire management community, but there is little research documenting how they are used and what influence they have on such factors as strategic selection and cost containment.
- **Develop new methods of fire planning and incident simulation**—Fires become more costly the longer they continue. At present, planning and incident gaming tends to focus heavily on initial attack. Tools, procedures, and processes suitable for use at the field level for planning and simulating megafires do not exist. Research effort needs to be placed on developing methods for simulating unit-specific incidents in terms of strategic decision-making and cost containment.
- **Examine the role and effect of incentive structures on fire management decisionmaking**—Incentive structures of individual managers have a potentially powerful effect on fire management decisionmaking. However, we have little research on how organizational policies, decision problem structures, and the risk-taking propensities of individual managers interact to influence fire management decisionmaking. Research needs to identify how organization policies and directives can take better account of individual incentive structures, and how the intentions of policy direction can be better

achieved by managerial structures that support managers in the decisions they make.

- **Develop education and training in risk assessment for fire and resource managers**—The future of fire and resource management likely will rely heavily on the methods and tools of risk assessment. Research needs to identify the best ways to train and educate fire managers in risk assessment, and to develop field-related approaches for delivering that education.
- **Develop better methods for representing values at risk**—Fire management is undertaken to protect values at risk. Making reasoned strategic decisions about fire management requires a value framework that allows values of various types to be compared and weighed against the costs of fire suppression. Research needs to be directed toward developing value frameworks that provide a stronger and more consistent basis for justifying fire-suppression costs.

Management of Integrated Research

Achieving progress on the research questions raised in this report will require appropriate management structures. By its nature, integrated research as described here will involve cooperative efforts of both research and field/operational personnel. Questions concerning the management of this research include:

- What research specialties and fire management specialties should be involved?
- What forum or institutional structures should be set in place to integrate research and field personnel?
- Should a coordination group be established to oversee the research, operating similarly to the National Wildfire Coordinating Group (NWCG). What role, if any, should or could the NWCG play in this research?
- Should the research be led principally by a research organization, or should it be led by a fire management organization?
- Should the research be defined as an initiative with a fixed term (e.g., 5 years), or should it be established as a permanent research program?
- Should the research even be given a programmatic definition?
- How should products of research be disseminated?
- Should the research form the basis for the establishment of a new research center for applied decision research?

Development of Intermediaries

Earlier we described the role for intermediaries who can translate field-related issues and questions into research hypotheses, and can translate research results into field-relevant applications. The development of these intermediaries should not be left to chance but rather be the result of deliberate actions of both the research and fire management communities. We should look for individuals who have the ability to bridge the information gap between the two communities and help them develop skills in assessing complex situations for information gaps, forming expert judgments, civic science, and communication skills.

Conclusions

The changing size, frequency and complexity of fire events are challenging the managerial skills of the fire community. The response has been to rely on greater integration of existing planning and analyses efforts, but this has been limited by the frequent lack of joint strategic thinking within the fire and land management communities. This will be especially the case where the design, location and timing of presuppression (most hazardous fuel treatments) activities can be integrated by the land management community within their planning efforts. It is also important to improve the strategic decisionmaking basis for analyzing fire management problems including cost containment.

We described a number of short-term and longer term research needs that could support expanded decisionmaking capabilities. Most of these involve synthetic efforts designed to be used in training to strengthen decisionmaking skills among fire managers. The emphasis on building skills reflects that the essence of decisionmaking is humans responding to situations often outside of the range of their experiences. Whatever we can do to both expand the range of experience and to increase the confidence of individuals to weigh risks, judge outcomes, and to communicate will result in decisions that entail lower costs and greater public acceptance.

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