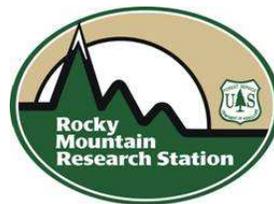
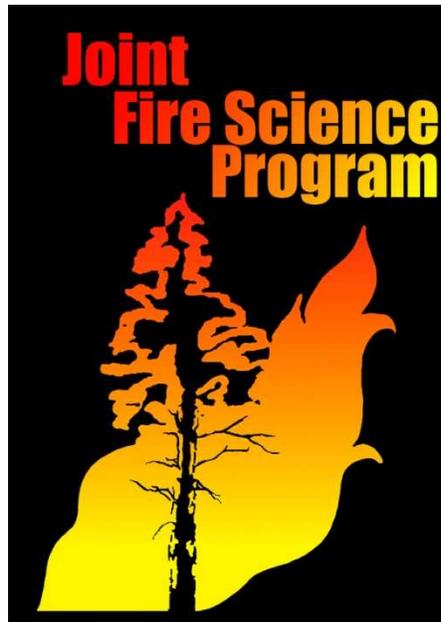


The interplay of AMR, suppression costs, agency-community interaction, and organizational performance - a multi-disciplinary approach.

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Abstract

Our collaborative project involved four interdisciplinary data collection efforts organized around understanding the relationships among cost, stakeholder and cooperator perspectives, agency-community interaction, organizational performance and flexibility in wildland fire management (known as Appropriate Management Response, or AMR in 2007 and 2008).

Our research design used a common sampling frame based on a fire strategy (see descriptions in Appendix A). Each of the four field studies used this common sampling frame to select study sites in 2008. The project has spurred on-going work in three of the four areas; this report covers activities through 2009. By using this approach, we provide land managers with scientifically grounded information about the interplay of fire management strategies/tactics and wildland fire management costs (to federal, state and local governments), stakeholder and cooperator perspectives, agency-community interaction, and key fire policy objectives (safety, value protection, ecosystem restoration), as well as a protocol for tracking progress.

Results were generated separately for each of the lines of inquiry, then integrated to triangulate findings and implications. Dissemination of research results followed a similar model: individual and integrated presentations were developed for different audiences, including: a) scientific meetings, b) management meetings, c) trade publications (e.g., *Fire Management Today*); and d) peer-reviewed publications.

Background and Purpose

While there is great interest in increasing flexibility in fire management, not much is known about what factors are associated with the ability to exercise that flexibility. In this research we refer to this flexibility in fire management as less than full suppression (LTFS) strategies. We sought to understand the role of different elements in shaping LTFS strategies, these included: how agency-community interaction increases or decreases the opportunity to exercise flexibility, how flexibility may or may not contribute to cost containment, including how fire managers, stakeholder and cooperator perceive costs of LTFS, and how strategies contribute to overall organizational performance. While these individual factors are important to understand, in the real world they have synergistic effects. With the notable exception of a research project on the Forest Service's management system dynamics (*Dialogos 2007*), most studies tend to focus on a single explanatory factor or outcome. Our research was unique in that it attempted to understand the interactive effects.

To accomplish this integrated research project, we sought a multi-perspective framework for understanding interaction and performance. We found one in the "balanced scorecard" approach (as described by Kaplan and Norton 1992), which recognizes and links customers, financial health, internal business perspective, and innovation and learning. We translated these into categories that worked within the context of our study: working relationships (stakeholder, cooperator and agency-community relations); cost (financial effectiveness); internal business (decision-processes and risk management involving safety, ecological health, tactical effectiveness); and organizational learning.

We leveraged the diverse disciplinary backgrounds on our research team (including economics, ecology, sociology, geography, and policy), significant connections to various levels of the federal fire management organization (particularly fire operations), and significant support from National Forest Systems' Fire and Aviation Management. This allowed us to initiate and carry out a broad field-based research effort.

Our research proceeded in separate streams that were integrated at the end of the study. Although we anticipated using different data collection methods, we sought to triangulate on a minimum of three fires representing the full spectrum of fire management strategies. These streams - cost, stakeholder and cooperator perspectives; agency-community interaction; and organizational performance – are described in greater detail below.

Costs, Fire Managers, State and Local Government Cooperator Perspectives: With the large increase in suppression expenditures by federal agencies over the past two decades, containing the cost of wildland fire suppression has been a topic of much discussion. Many policy and decision-makers hope that the use of less aggressive suppression strategies, where appropriate, will result in lower costs (OIG 2006, USDA and USDI 2007, NRCG 2007). However, the interplay of wildland fire management decisions and cost containment is not well understood. Additionally, the issue is more complicated than the direct costs associated with wildland fire suppression efforts. When choosing a fire management strategy and implementation tactics, fire managers likely take into account cooperator, public and internal expectations and acceptance. Though cost is an important aspect, perceptions of cost may vary depending upon whether the audience is internal or external. Further, costs may be more of an outcome than a driver of choice of strategy. Acceptance of fire management activities by non-federal agency partners may be influenced by perceptions of who bears direct and indirect costs associated with different suppression strategies and tactics. Federal agencies frequently track direct costs; however, cooperators may be most concerned with indirect costs. Understanding and addressing such varied concerns could influence use of LTFS by affecting which strategy stakeholders perceive as most likely to reduce overall costs, burn time, fire severity, and risk.

It seems apparent that the strategies used to suppress a wildfire should affect its cost. Conversely the increasing emphasis on cost containment should affect the strategies used. Yet, there is little systematic documentation of how these two elements interact. Additionally, information is needed on how fire managers, and non-federal cooperators view the effect of selected strategies and tactics on costs, since the way a wildfire is handled may have effects beyond the cost of suppression itself. To begin to understand this complex issue we conducted both quantitative and qualitative research to address the following questions:

- 1) How do wildland fire management strategies and tactics influence wildland fire costs?
 - (a) Does less than full suppression result in reduced suppression costs by the federal agencies?
 - (b) Do strategies and tactics aimed at less than full suppression simply shift the cost burden to non-federal entities?
- 2) How does an increasing emphasis on cost containment influence the strategies and tactics used on wildland fires?

Agency-Community Interaction: Fire managers must take into account public expectations and acceptance of different fire management strategies and tactics. Understanding how agency-community interactions shape both public acceptance and manager’s perceptions of what is acceptable is therefore key to ensuring long-term flexibility of management choices. In this portion of the study, we sought to understand the relationships of pre-fire and during fire community interaction with fire management flexibility by addressing the following questions:

- 1) Does agency-community interaction before and during a fire give managers the greatest flexibility during the fire event?
 - (a) Does outreach and interaction with the public prior to the fire, including involvement in land management and fire management planning and hazard mitigation, increase acceptance of

- less than full suppression during a fire?
- (b) Does a clear explanation to the public during a fire of what actions are/are not being taken and why and discussion of their expected effectiveness increase acceptance of less than full suppression strategies?

Organizational Performance: Ability to use LTFS strategies also hinges on how well fire managers are able to articulate their objectives and implementation processes, and communicate outcomes in light of those objectives – in essence, performance. Yet, at the beginning of this project, there were no consistent assessment criteria or data collection protocols through which to describe or understand incident and fire management performance. Considerable data exist, but they had not been systematically captured, collated or analyzed to provide a consistent picture of performance. The goal of this portion of the project was to identify and apply to incident management a scientifically grounded approach to performance assessment and improvement. However, simply capturing data to populate a ‘balanced scorecard’ without a clear vision as to how to use the data to improve operations seemed effort wasted. Thus, we sought an approach that allowed us to understand performance in light of research on high reliability, organizational learning and performance enhancement.

Our objectives were to:

- 1) Refine and test a performance process that can be implemented with limited effort nationwide that tells a consolidated, comprehensive story of how annual fire expenditures are/are not meeting fire policy objectives by testing tentative measures in the Northern Rockies; and
- 2) Clarify how decision-makers weigh potentially competing fire management objectives and risk (long vs. short-term risks, safety, cost, probability of success, public opinion) and determine whether there are patterns to these weights across strategies.

Study Description and location

What was intended: Our intent was to sample large fires in 2008 in the Northern Rockies and one or two other geographic areas (GACC) that represented the full spectrum of fire management strategies. Focusing on a single geographic area like the Northern Rockies provided for in-depth study to develop a thorough understanding of effective practices, challenges, and how to measure progress. Broadening the scope for agency-community interaction and cost outcomes would allow comparison across fuels, weather and season to detect the influence of management capacity and social context on fire management outcomes.

We utilized multiple methods to collect data including quantitative and qualitative data, as appropriate to the research questions and objectives for each sub-area of research..

What actually happened: Fire activity was minimal in the Northern Rockies in 2008 and highly concentrated in northern California. We were able to proceed with some data collection by expanding our geographic scope.

Cost: To determine whether costs vary consistently with strategy, we identified two potential methods. Both consider the predominant strategy employed, with the unit of observation for the first being an individual fire, and day or a group of days with a similar strategy for the second. We dropped this second method because the data were not readily available and an effort to collect this type of detailed data on past fires was not deemed feasible.

We worked with several FS and DOI fire managers to develop a classification scheme, settling on two objectives (protection and resource benefit) and five strategies. Strategies under the protection objective were: direct suppression, modified suppression, and limited suppression.¹ Strategies associated with the Resource Benefit objective included: area monitoring and area management.² (See Appendix A for the full description of the objectives and strategies).

Our population of fires came from a subset of data maintained by the Rocky Mountain Research Station (see Gebert et al. 2007 for a description of the data collection process). We restricted our analysis to fires occurring in FY 2006, 2007 and 2008 to limit the number of fires requiring categorization. To collect the information on Forest Service fires, a spreadsheet was sent out to the field as a formal data request by the Washington Office. For the DOI fires, the spreadsheet was sent out to the field by NIFC fire management personnel. The response rate to the data request was extremely good. We received information on 566 of the 574 FS fires requested. For the DOI (except the BIA), we received information on 719 of the 823 fires requested. We received no information from the BIA. The Resource Benefit fires in our study included only those fires that either: 1) became a suppression event at some point in the fire or 2) were managed for multiple objectives (with resource benefit the primary objective). This latter set is only applicable to FY 2008 fires that occurred in the pilot areas for implementation of the new interpretation of federal fire management policy. Fires managed solely for resource benefits are not included because they were not included in the database maintained by RMRS.

We analyzed this data using two different approaches: a comparison of means (an ANOVA approach using a General Linear Mixed Models procedure) and regression analysis. For the means analyses, several dependent variables were assessed: total cost, per acre cost, acres burned, daily cost, and duration. The factor, in each case, was the predominant suppression strategy. Although our classification of objective and strategy consisted of five levels, the two Resource Benefit categories were combined resulting in four categories. For the regression approach, we used regression equations that have been developed and used for estimating suppression costs on large fires. These equations are currently used in both WFDSS and as an after-season performance measure (see Gebert et. al. 2007).³ Six equations have been developed: two for the Forest Service (Western and Eastern U.S.) and four for the DOI (one for each agency). The dependent variable in each model is federal wildland fire suppression expenditures (either per acre or total) and the independent variables consist of fire characteristic information on the fire environment (slope, elevation, aspect, fire intensity level, energy release component, and fuel type), values at risk (distance to the nearest town, total housing value within 20 miles of ignition, and whether or not the fire started in a wilderness area and the area to the boundary), and geographic region. To test the effect of strategy on suppression expenditures, a set of dummy (zero/one) variables reflecting strategy type were included in the equations

Fire Manager, and non-federal Cooperator Perspectives: During fall of 2008 and winter 2009, a two-person interview team conducted 25 in-depth, unstructured interviews with 30 persons whose jurisdictions were affected by large wildland fires in 2008. These represent fire managers (agency administrators, incident commanders) and non-federal cooperators (elected and/or appointed state and local government officials, such as county commissioner, state forester, or state/local fire organization).

¹ For the FS, these categories were called P1, P2, and P3 due to concerns from management about the category names.

² For the FS, these categories were called RB1 and RB2 due to concerns about the category names.

³ These equations have been modified somewhat since the 2007 publication but the basic variables and methods have remained the same.

The five focus fires, drawn from four western Forest Service Regions, ranged in size from less than 4,000 to over 65,000 acres. Federal costs ranged from nearly \$3 to \$13 million; all burned solely on Forest Service lands. The fires were mostly long duration, with the shortest at 18 days and the longest over 90 days. Strategies and tactics employed run the gamut from full direct suppression to limited aggressive suppression activity. Data were analyzed using qualitative data analysis methods and analysis software.

Agency-Community Interaction: In 2008, we conducted research at three fires—the Gap, Cascade and Gunbarrel—each of which used a different strategy for managing the fire. At each site, we interviewed federal agency individuals who played a role in managing the fire, and key local agency and civic leaders associated with the fire as well as members of the general public. We asked them about pre-fire communication activities, during fire communication activities, what did and didn't work for them, and their perspectives on how the fire was being managed. The Gap Fire (suppression/full perimeter containment) on the Los Padres National Forest burned nearly 9,500 acres in Santa Barbara County near the town of Goleta. The Cascade Fire (modified suppression/perimeter containment) on the Custer National Forest burned more than 10,000 acres near Red Lodge, Montana in Carbon County. The Gunbarrel Fire (wildfire use to monitor, confine and contain) on the Shoshone National Forest burned more than 68,000 acres near Yellowstone National Park in Park County, Wyoming. Data were analyzed using qualitative data analysis software.

Joint Fire Science project managers requested that we conduct confirmatory studies in 2009 to follow up on the findings from 2008 interviews. In 2009, North Carolina State University conducted a survey of 1,000 community members affected by the Hat Creek Complex in northern California. The objective of this research was to verify or refute communication patterns detected in the qualitative analysis of the Gap, Cascade and Gunbarrel Fires. Due to lower than expected fire activity in 2009, we were able to conduct only one survey and deferred the second, confirmatory phase or our community interaction work to the 2010 field season. Analysis and results from the one survey are reported here, and results from the remaining surveys once completed will be posted to this project site.

Organizational Performance: In 2008, we designed a Key Decision Log (KDL) to capture decision-making and performance pertinent to each of the standard fire objectives. Decision-makers (agency and incident management team members) document their decision process – decision, alternatives considered, decision rationale, factors affecting the final decisions, costs of alternative actions, and consequences for decisions having a significant impact on costs, social/political relations, or resource allocation. The initial KDL concept was developed in a collaborative effort between the Rocky Mountain Research Station and the Northern Rockies Coordination Group. Originally expected to be piloted in the Northern Rockies, the effort was further developed as part of Forest Service's Accountable Cost Management Action Plan for FY08.

In 2008, the KDL was accessible on-line for Forest Service employees, and as a download –able electronic file for users from other organizations. KDLs were submitted for 28 incident covering the full gamut of incident types and incident management organizations, from Type 1 events to Wildland Fire Use (now known as Resource Benefit fires); from Area Command and unified command to National Incident Management Organization teams (NIMO) on fires in six National Forest System Regions, USFWS, BIA lands. A number of Forests created, but did not submit, KDLs. Entries represent large fires, Initial Attack, Extended Attack and Type 4 and 5 events.

Feedback and experience in 2008 was used to revise our approach. One consequence of this was dropping a number of the specific performance measures in favor of understanding the nature of decision-making itself.

In 2009, we pursued proof-of-concept testing for a measure of ecological impact outside the KDL. This metric utilizes historic fire severity data from the LANDFIRE data and compares this to immediate post-fire data of similar resolution generated by the Remote Sensing Application Center (RSAC). RSAC currently produces a number of post-fire severity algorithms. The RAVG dataset (Rapid Assessment of Vegetation change) appears to be the most relevant for our purposes. We were able to obtain results for 13 fires (2008 and 2009) and ascertain that if acceptable to the field, can be quickly and efficiently generated for all fires (see Key Findings). We plan to pursue this further.

In 2009 we also released a stream-lined, web-based version of the KDL accessible to all users on the inter-agency FAMWEB test server. Each GACC and some National Forests identified a KDL Manager responsible for authorizing access to new users. Direction for use, largely from Geographic Area Multi-Agency Coordination Groups and Regional Foresters, focused on Type 1 and 2 incidents on Forest Service jurisdictions in FS Regions 1, 2, 4, 5, 6.

The KDL was used on 41 incidents in 2009 –full, modified and limited suppression strategies managed by Type 1 and 2 teams, as well as long-duration events managed for Resource Benefit or less than full perimeter control, and prescribed fire. Users served represent the entire inter-agency community: local government, states, all Department of Interior land management agencies, and seven Forest Service regions. Products in 2009, in addition to those created on-incident by IMT and Host units included: compilation of ‘Lessons Learned’ drawn from the ‘outcomes and learning’ fields; development of two fire narratives that compile and compare incident direction and incident outcomes; summary statistics and graphical analysis of the database to assess patterns of attention, decision types and rationale. Data are being analyzed using a combination of summary, quantitative descriptive statistics and narrative analysis.

Key Findings

Costs

Results varied depending upon how “cost” was measured. [Note: The following results do not include fires managed entirely for Resource Benefit; all included in that description were also managed for protection objectives.]

1. Study results indicate that if the concern is with decreasing annual suppression expenditures, or lowering per fire expenditures, less aggressive strategies may not equate to lower costs.

The results from the analysis of means suggested that less aggressive protection strategies do not lead to lower average fire costs. The results were most apparent for the western regions of the Forest Service. For the western Forest Service regions (1-6), the average cost for “modified” suppression events (\$7.3 million) was higher than for any other category, with the differences being highly statistically significant. The average cost of the other strategies (direct, limited, and primarily resource benefit) were not statistically different from one another, with average costs of \$4.3 million, \$3.7 million, and \$3.6 million, respectively (Figure 1). Although modified suppression events had a lower per acre or daily cost than direct suppression events, the much larger acreages and longer duration (nearly twice as large and twice as long) of these modified suppression events led to a higher overall cost (as an example, Figures 2 and 3 show the average daily cost and duration by predominant strategy). When compared to the two lesser aggressive strategies, the higher per unit cost of the modified suppression events, coupled with smaller differences in acreage or duration, led to the higher total cost for modified suppression. The average cost of direct suppression, limited suppression, and primarily resource benefit events in our sample were not statistically different.

The higher per unit costs of direct suppression events were offset by the longer duration and larger acreages of the limited suppression and resource benefit events, leading to similar costs.

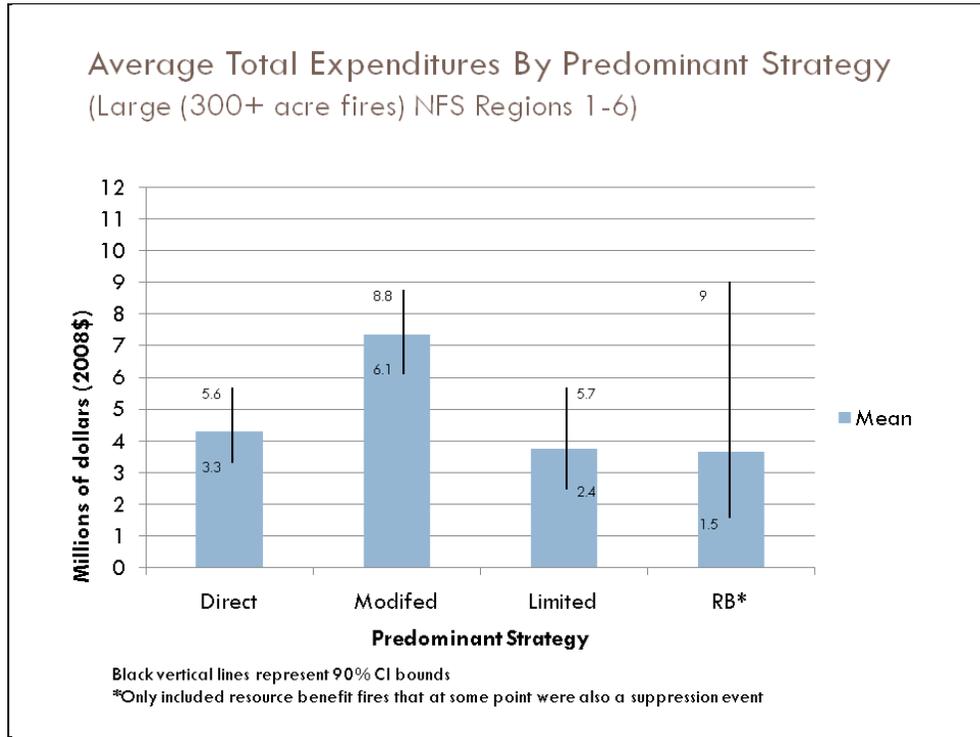


Figure 1. Average total expenditures by predominant fire management strategy

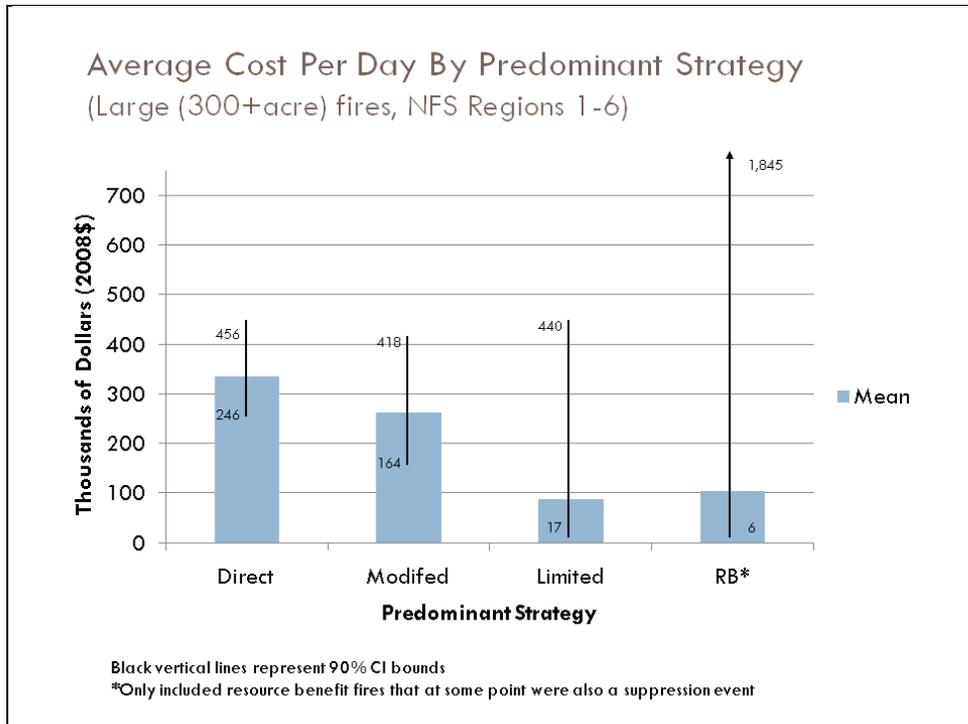


Figure 2. Average cost per day by predominant strategy

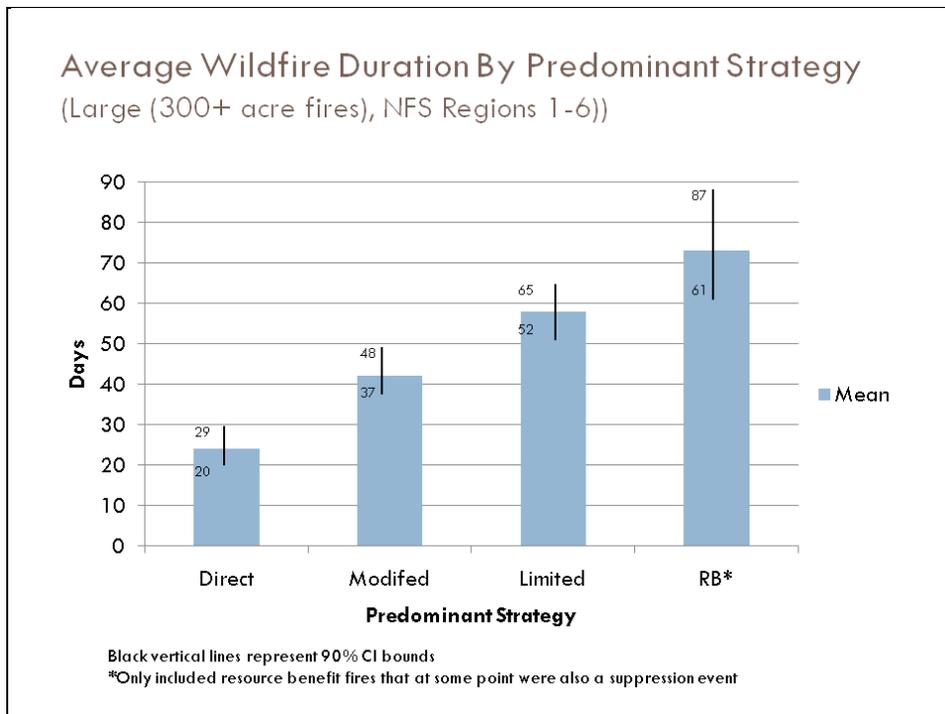


Figure 3. Average duration by predominant strategy

Results were similar for Region 9 (all fires in Region 8 were classified as direct suppression) For Regions 9, modified suppression events had a higher average total cost (\$1.1 million) than direct suppression events (\$354,000), due primarily to a much larger average area burned. For the DOI, the differences in average cost between fire types were not statistically significant, though the same patterns emerged.

- Results indicate that on a per unit basis (per acre or per day), less aggressive protection strategies do equate to lower costs. Also, when all other fire characteristics are held constant (the same size fire, the same duration, same characteristics...), a “limited” suppression strategy or a “resource benefit” strategy is less expensive than direct suppression.**

When looking at the results for a “per unit” basis, whether per acre or daily costs, the pattern of costs equates to the conventional wisdom that less aggressive strategies are less expensive. Direct suppression has the highest per acre cost, and the costs go down as the strategies become less aggressive, with the differences being statistically significant (Figure 4). For daily costs, the costs also decrease with less aggressive strategies, but the differences are not statistically significant. The regression analyses (whether OLS or 2SLS) also indicated that limited suppression and resource benefit fires are less expensive than direct suppression, when ALL ELSE IS HELD CONSTANT. That is, for fires of the same size, same duration, same fuel type, and so on, limited suppression and resource benefit fires are less expensive. These results held regardless of the whether assessing cost per acre, daily cost, or total cost. However, even for fires with similar characteristics, acreage, and duration, modified suppression events were not less expensive than direct suppression events. However, it is important to remember that, usually, all things are not held constant. As mentioned previously, less aggressive strategies equate to longer duration and more acreage which can have significant impacts on cost.

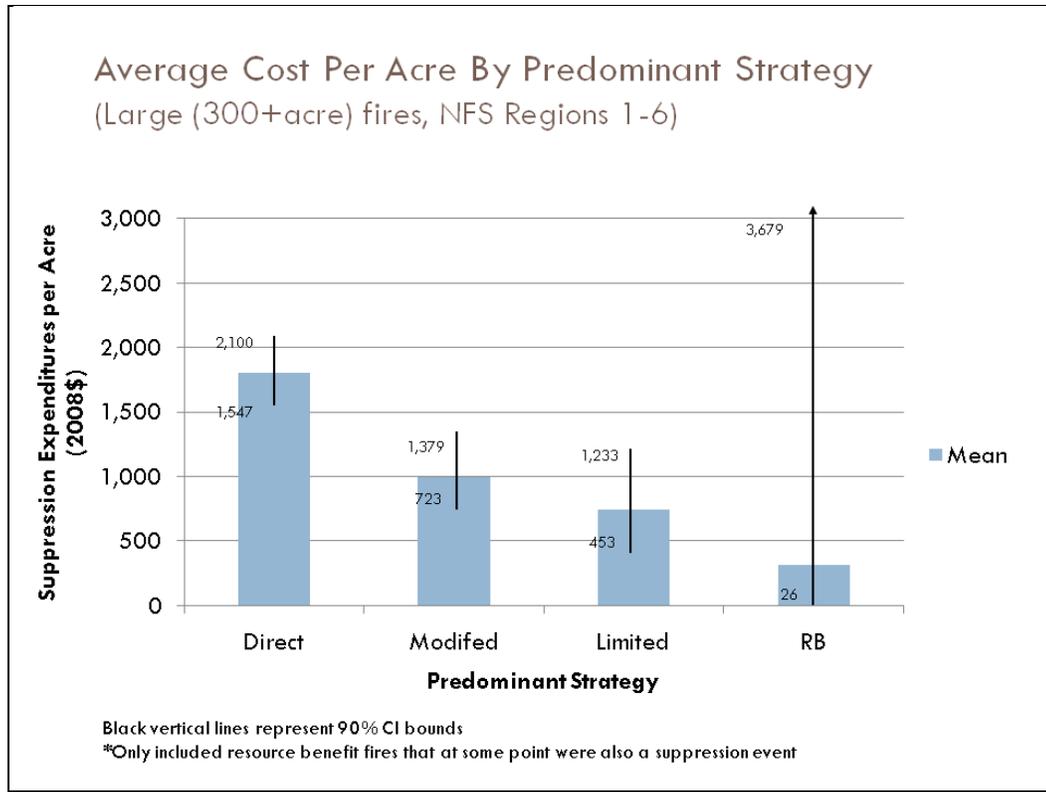


Figure 4. Average cost per acre by predominant strategy

Fire Manager and non-federal Cooperator Perspectives

3. **There is strong concern among non-federal cooperators that, although less than full suppression strategies may lead to cheaper suppression costs per acre, the fact they often result in longer duration fires may push total costs to figures similar to or greater than those of full suppression strategies.**

A general belief among federal land managers is that *less than full suppression strategies lead to cheaper wildland fire suppression costs*. Indeed, Federal agency interviewees believed this to be so, provided the fires meet certain criteria including: they are of short-duration; they provide improved forest health or involve low values at risk; they represent little threat to firefighter/public safety; and they are of little social/political interest. They stated that in terms of cost per acre, fires managed with less than full suppression strategies were typically cheaper. However, there is strong concern among non-federal cooperators (as well as some land managers) that the use of less aggressive strategies often can result in long-duration events and that a majority of fires for which less aggressive strategies are used blow up into larger than expected events, producing unforeseen socio-economic impacts. Their perception is that long-duration fires, typically associated with LTFS, are very costly and consume Agency non-fire program budgets and that the Agency’s increased emphasis on wildland fire cost containment is a pervading influence on decisions to select LTFS strategies. Long-duration fires managed under a less than full suppression strategy are also to cost more for structure and private property protection because they are often associated with extreme, unpredictable weather events, which increase threats to non-agency areas.

The five fires in our study ranged from 18 to 60 days in length. Interviewees considered the costs of these fires to be high and many thought that they were higher than they might have been had they been managed under a completely full suppression strategy once they escaped initial attack.

4. Non-federal cooperators felt that primarily because of the longer duration of LTFS fires, these strategies lead to greater impacts on them, including increased monetary costs,.

Less than full suppression strategies were seen to lead to long-duration fires, which a number of interviewees felt resulted in greater impacts on cooperators. Non-federal cooperators mentioned both monetary and non-monetary impacts. While cooperators in this study did not accrue structure protection costs for the incidents, they nevertheless believe that *direct* protection costs will devolve increasingly to them as federal agencies embrace a more flexible approach to strategy selection. In particular, cooperators are concerned about costs accruing from the Agency's adoption of fire for resource benefit strategies. They felt there was a rise in their direct protection costs for federal fires managed under a less aggressive strategy. Cooperators discussed higher monitoring/preparedness costs and higher opportunity costs (for example, their resources became unavailable for response to other emergencies in their protection area), as well as reported protection area resource losses. Cooperators indicated they were becoming less willing to engage in cost share agreements with the Forest Service if their costs increase because the agency has opted to emphasize less than full suppression strategies.

City and county governments in the vicinity of fires studied for this project described increased opportunity costs and out-of-pocket expenses associated with these long-duration fires, which they believe were encouraged by the agency's selection of less aggressive suppression strategies. Business costs that some felt were associated with the long-duration fires included increased farm, ranch, and private timber business costs, as well as declines in recreation and tourism businesses. In addition, local government officials believed they were usually required to spend much more unreimbursed time dealing with public meetings and citizen concerns because of the fires.

Agency -Community Interaction

5. More effective pre-fire and during-fire communication was present on those fires where more flexible fire management strategies were used.

Our working hypothesis was: *Pro-active communication before and during the fire facilitates more flexible fire management during the fire.* We did not reject our hypothesis: More effective pre-fire and during-fire communication was present on those fires where more flexible strategies were used.

The **Gap Fire** experienced several communication problems. This fire had a complex interface that involved a large population base and numerous government agencies and municipalities. The emphasis of pre fire outreach efforts, in which Santa Barbara County played a large role, was primarily on defensible space. During the fire communication activities were handled primarily through the news media, kiosks, and a call center. Interviews indicated community members had a number of issues with communication during the fire. They identified confusion over evacuation areas, an overwhelmed call center, InciWeb going down, power outages, and ineffective communication during news conferences. One member of the public felt the communication effort was "insulting" because all the fire fighters and visiting officials were thanked for 20 minutes before information about the fire was given out.

The **Cascade Fire** experienced few communication problems. The local forest, in conjunction with the County, had done some pre-fire communication including working on fuel reduction projects and FIREWISE practices. The County had also worked on evacuation drills. During the fire

communication efforts included standard news media, frequent community meetings, and daily distribution of fire information at all the stores on the main shopping street. Overall, interviewees identified were quite satisfied with communication during the Cascade Fire. Key informants claimed that communication was, “...as good as I’ve ever seen it in any fire” and “I didn’t hear any [complaints]... they put out a lot of information that I think satisfied a lot of people”. Members of the general public stated, “...they were very forthcoming” with information and that they were thankful to have “accurate information to counter balance a very natural, natural, sensible fear”.

The **Gunbarrel Fire** experienced few communication problems. Prior to the fire, the local forest had engaged in extensive work, including a media tour, to communicate fuel conditions in the forest and how a fire likely would be managed should it occur. Fuels projects in the region removed 8-10 million board feet of hazardous fuels around summer homes /lodges through mechanical thinning and prescribed burns. Local USFS employees worked cooperatively with local government, actively volunteered in their community, and held an annual picnic with property owners. During the fire communication efforts included standard news media as well as community meetings in multiple locations, kiosks, a daily email information distribution and one on one visits. Interviewees identified several positive communication trends both before the fire and during the fire. Key informants stated, “...it’s all positive... I can’t say enough about how they have been forthright”. In commenting on how the local Forest Service had done a good job educating the public, a community member commented, “... I have heard, with very, very few exceptions, that the public understands” about the condition of the forest. A member of the general public observed, “I don’t think you could beat what they put out”.

6. The public finds information from official agency sources (local Forest Service representatives, maps, IMT representatives) more trustworthy and useful than other types of information sources during the fire.

Survey respondents were most likely to use the following types of information during a fire: family, friends, neighbors (88%), local regional newspapers (84%), local/regional television (83%). However, they most trusted the local Forest Service (69%), maps (60%), family, friends and neighbors (59%) and IMT representatives (56%).

7. There are different communication needs at different times during the fire. During the most crisis-driven times of the fire, the public wanted the following information: 1) Where is the fire going and where is it likely to go? 2) How does the fire affect me? 3) What should I be doing?

Data from interviews in 2008 and from the survey in 2009 support this finding. Ninety-four percent of survey respondents indicated they “wanted very much” information about the status of the fire, 81% indicated they wanted to know “where the fire is” and 78% wanted to know about fire hazards and concerns. This was affirmed in a confirmatory question which asked which types of information were “very important” to respondents during the fire. Eighty-eight percent indicated they wanted to know “where is the fire likely to go?” and “where is the fire going?” (Figure 5). An additional 73% indicated they wanted to know “what should I be doing?”.

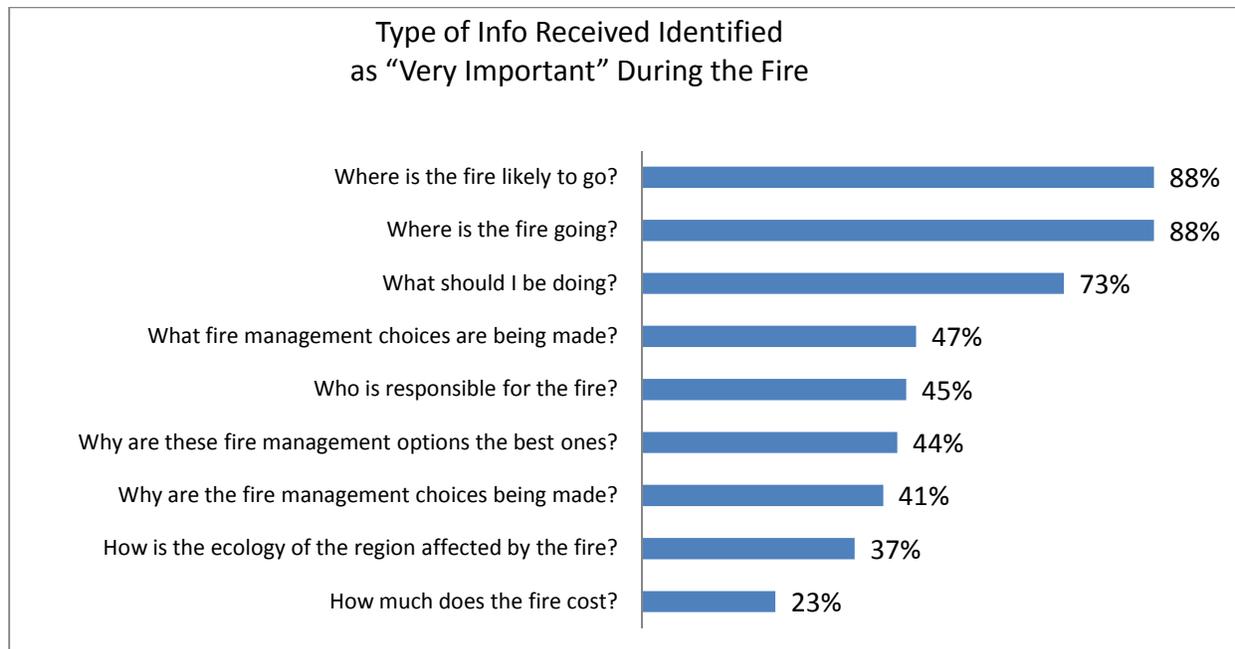


Figure 5. Percentage of respondents who consider various types of information ‘very important’ during a wildland fire incident (n=133).

- 8. Educating the public about the changing nature of fire management and associated costs may be a challenge for federal agencies because this information is less important to the public than other types of information during the fire.**

Fewer survey respondents rated information about “fire management strategies”, “what fire management choices are being made?” (47%), “why are fire management choices being made?”(41%), “why are these fire management option the best ones?” (44%) as “very important” to them compared to fire status information, where the fire is and what they should be doing during the fire.

Organizational Performance

- 9. By capturing key factors of the decision-process consistently across multiple individuals and teams, the Key Decision Log provides insight into organizational processes and features that constrain or promote effectiveness. A web-based system facilitates accessibility and evaluation.**

KDL2009 results indicate that while some aspects of incident management – ramp-up and ramp-down decisions, for instance – are performed consistently and without undue concern, other aspects – cost-share agreements and unified command – are sources of tension and stress.

Results also indicate the types of conditions that capture attention. For instance:

- fire behavior/activity, operational efficiency, fire fighter safety and values at risk were most frequently cited as creating the need for a decision, action or concern.
- Less than 20% of all KDLs but more than 50% of incidents, identified ecological effects as a condition requiring attention. Where additional detail was provided, most concerned actions to *minimize* impacts - weeds, invasive aquatic species, impact to critical watersheds, caribou habitat and old growth. With the exception of one log that noted fire as a desired

process in wilderness, no mention was made about the potential *benefits* of fire to specific species, habitat, future fuels conditions or future landscape condition. There was more discussion of ecological effects on incidents managed by the home unit, during the earlier phases of a fire, and for a fire use event.

- Only 'political climate' and 'incident-within-incident' were noted less frequently than ecological effects as a condition requiring attention.

Such information is useful for identifying where focused management effort might provide greatest payoffs in terms of improved efficiency and effectiveness.

10. The centralized KDL database allows quick and effective capture and dissemination of lessons learned and effective practices; a critical function for organization-wide learning.

The centralized database diminishes the isolation normally found on incidents and teams. At the request of users in 2008, an attribute field was added for 2009 to allow notations of lessons learned and effective practices. Submissions in 2009 covered a range of issues from agreements to communications to effectiveness of fuels treatments to new technology. For instance, teams noted or posted:

- Logistics – a Verizon Crisis phone number thru which they were able to obtain a booster tower and wireless cards for the Incident Command Post.
- Fuels Treatment – how previous fuels treatments assisted with achieving containment objectives, and the cost associated with those activities.
- Safety – the results and improvements to their incident-within-incident protocol after having to implement it.
- Liaison Officers – the value of designating a lead LO when multiple units were involved.
- Operations – lessons from operating in an area of heavy snags from a previous high severity fire; speeding up transitions by inserting certain operations personnel prior to formal transfer.
- New technology/protocols – results of a pilot effort to use packing lists to track and account for Cache shipments.

11. An incident KDL provides a quick reference, and text, for a final fire narrative that links incident direction with outcomes – providing the how and why a group or set of groups moves from articulating intent and direction to achieving actual outcomes.

Essentially an electronic unit log, the KDL creates a near real-time trail of decision-points and reasoning useful for during and post-fire assessments. By capturing the tracks decision makers leave during an incident the KDL provides a report useful for tracking a team's progress, developing the final documentation, and as a reference for post-incident and post-season review.

By collecting intent and outcome in one place, it can assist in understanding the degree of connection (or gap) between what is intended and what actually happened. Exploring the links between land management plan direction, Line Officer intent, and implementation can help identify ways to better articulate and communicate initial direction, decision-making and risk assessment processes and outcome reporting. This sort of document allows the Host agency and incident managers ask questions - how well are our decisions aligned with leader's intent and what would it

take to notice/respond differently, or the same manner next time? - leading to a discussion of how to improve that for the next fire.

12. A 'balanced scorecard' using KDL2009 entries reveal an emphasis on Internal Business, followed by Working Relationships; and a tool useful for objectively understanding the types of conditions that influence outcomes.

Categorizing KDL entries into the balanced scorecard groups shows that the bulk focus on Internal Business, but almost a quarter have to do with working relationships (Figure 6). For this analysis, *Working Relationships* includes closures, communications, coordination, evacuations; *Internal Business* includes containment, direction, ecology, logistics, planning, progress, reconnaissance activities, safety, staffing, strategic direction, and tactical action; *Finances* includes KDLs that spoke exclusively and specifically to finances; *Learning* captures KDLs that track a new process – the GETA technology, for instance. More detailed analysis of Internal Business KDLs reveals that most of these concern operations and safety.

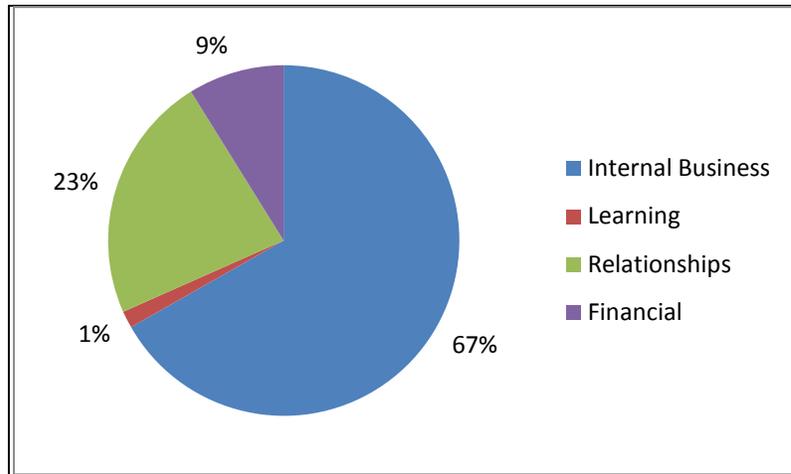


Figure 6. KDLs summarized by the quadrants of a 'balanced scorecard'.

While the majority of KDLs concern actual decisions – implementing strategic objectives – a significant proportion concern issues or actions that require attention, but do not rise to the level of a decision (Figure 7). Such a finding implies that in order to understand and improve risk-based decision making, we need to consider more than just what is formally termed a 'decision'.

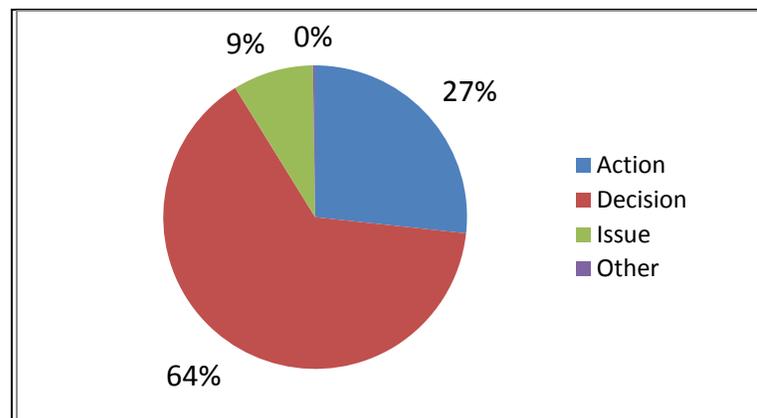


Figure 7. Summary of KDLs by 'Entry Type'.

13. Data comparing immediate post-fire burn severity to historic fire regime severity can be efficiently generated. These datasets are available nationally, providing quick, consistent assessment of departure from/congruence with an important ecosystem-scale aspect of ecological impact.

Ecological impacts of wildland fire are currently captured in ‘acres burned’ and ‘acres of high severity fire’. The former provides a poor measure of ecological impact, leaving the impression that any acre burned is ‘bad’. The latter does not distinguish areas that naturally burn with high severity from those acres that have burned at an un-natural, and thus likely debilitating, severity. While the metric piloted here also suffers from limitations, for instance – lack of information about burn patterns – the datasets used are amenable to spatial analysis.

We obtained data for 13 fires as a proof-of-concept (Data are available for all fires over 1000 acres). As illustrated in Figure 8, we collapsed the historic fire regime classifications in order to highlight severity class. We then compared this to Basal Area loss as measured by the RAVG algorithm being assessed by the Forest Service’s Remote Sensing and Application Center. Our results demonstrate the ability to quickly (within 14 days of a fire) summarize departure from historic fire severity. With additional data, we can determine whether there are significant differences in this pattern by fire management strategy.

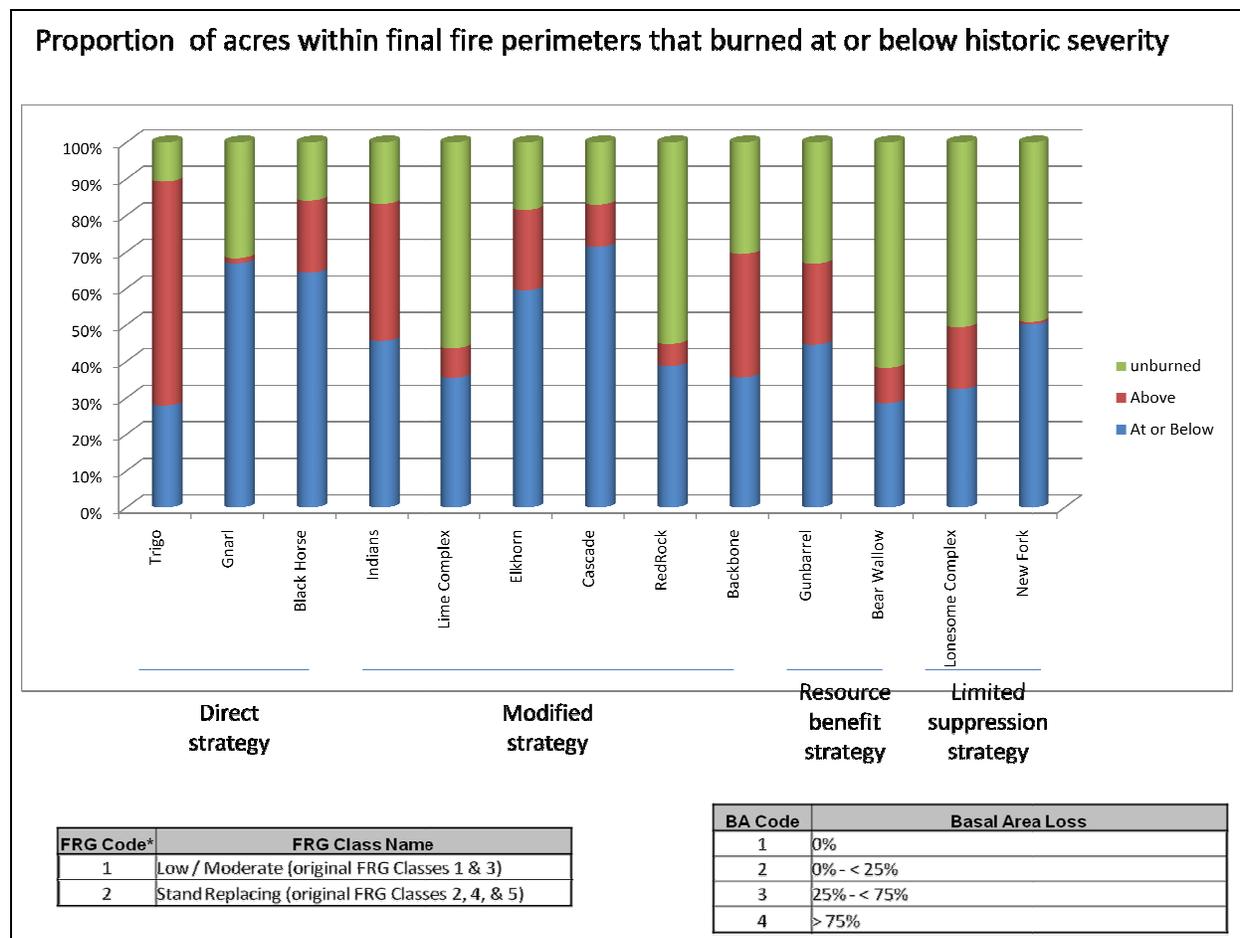


Figure 8: Actual fire severity (measured by the RAVG algorithm) compared to historic fire severity (collapsed into two categories from the LANDFIRE dataset) for 13 wildland fires (2008 and 2009) organized by fire management strategy.

Management Implications

Costs

- 1. Fire management strategies should be selected based upon land management objectives, with cost being a byproduct of good management decisions.** Our study indicates that in the short term less aggressive strategies may not save money. That is, on an annual basis, less aggressive strategies may end up costing the same as or more than full suppression due to the longer duration and larger size associated with the types of LTFS studied here. However, it may be that modified suppression was chosen because features of the event (such as fire weather, accessibility, fuel conditions, fire-fighter safety concerns) make direct suppression impossible. Thus, the high cost of modified suppression fires may be due more to the nature of the fire, than the strategy employed.

Fire Manager and non-federal Cooperator Perspectives

- 2. Financial cost is only one of several important measures: less aggressive strategies may meet land and incident management objectives besides cost.** In the long-term, less aggressive strategies may equate to future reduction in wildfire duration, size, severity, suppression costs and perhaps less firefighter exposure due to reduction in hazardous fuels. Other potential benefits include fire effects and increased ecosystem resilience which help meet land management objectives. Determining how to consistently characterize these non-monetary and non-federal benefits and costs could assist in understanding the value of each management strategy.
- 3. Perception is reality.** Narrative analysis of interview data with cooperators provides information about why cost shifting is of concern and where the concerns may have originated. Cooperator perceptions often included costs' beyond monetary outlays for fire suppression activities. Many interviewees spent considerable time discussing indirect financial impacts (e.g. to local businesses) as well as direct and indirect non-monetized impacts (such as health and aesthetic issues).

Better understanding of the reality of such perceptions can better equip the Forest Service, and other federal fire agencies, to address these concerns. Although interviewees did not provide (nor did we find or seek) concrete data concerning such additional direct and indirect costs, acceptance of the effect of LTFS strategies as conventional wisdoms can influence Agency and community response to the manner in which fires are managed. The ability of Agency managers to make use of all possible strategies may be influenced by such perceptions if conventional wisdom is not challenged with open discussion and analysis of true costs associated with fire management strategies.

Agency-Community Interaction

- 4. Pre-fire and during fire communication can facilitate more flexible management.** Our data indicate that more flexible fire management strategies were used in the site where more effective pre-fire and during fire communication took place. This suggests that if more flexible fire management strategies are a policy goal, then better communication needs to take place between the agency and the local community before as well as during the fire. Better communication before the fire can take the form of evacuation drills, media tours, outreach to home owners, education about fire ecology and likely fire management strategies, and providing information about defensible space/FIREWISE and hazardous fuel reduction projects. During the fire, pro-active communication

means delivering direct, credible and accurate information about where the fire is going and how people will be affected by it.

5. **Official information sources are most trusted and useful to the public.** Our data indicated that residents trust and find useful the information given to them by local Forest Service and IMT representatives. However, these sources are not leveraged well by the public, compared to other sources, during the fire. This suggests the need to increase the presence of these valuable resources within the community during and before the fire.
6. **During fire communication should focus on fire status information and what residents should be doing.** Our data indicate that IMTs and local forest representatives should try to meet the demands of local residents by delivering the information they most want. This includes information about: where is the fire going, where is it likely to go, how does the fire affect me, and what should I be doing?
7. **Educating the public about the changing nature of fire management and associated costs may be a challenge for federal agencies because this information is less important to the public than other types of information during the fire.** Our data indicate that while the agency may want to focus on issues related to cost and greater flexibility in fire management that the public is less interested in this type of information during the fire than others kinds of information. This means the agency may need to focus on delivering this information prior to the fire or ensuring that other information demands of the public are met before trying to educate them about cost and fire management concerns.

Organizational Performance

8. **The absence of criteria or concrete objectives hinders assessment of effectiveness.** The search for effective and efficient performance measures is complicated by a lack of criteria for or description of what constitutes 'success' in incident management. Success, in the eyes of incident commanders, is consistently expressed as 'meeting the line officer's objectives as outlined in the Letter of Delegation' (Black et al. 2007). However, how to assess progress and/or final outcome is universally unclear. In such circumstances, actions speak in place of words. In the KDL we can identify what decision-makers' pay attention to and how they balance and negotiate priorities in the course of implementing the chosen strategy. This provides members of the fire management community usable feedback with which to gain additional and objective insight into their own and the system's operating dynamics. One aspect of this is the ability to reflect on how to articulate criteria and/or objectives that can be most easily tracked and assessed post-assignment or post-incident.
9. **Understanding decision-processes-in-use contributes to organizational performance improvement.** The Key Decision Log captures information at an individual/team-level thus allowing team-by-team, or host-unit reflection and learning. By capturing such information consistently across multiple individuals and teams, it also provides additional insight into organizational processes and features that constrain or promote action.
10. **The KDL provides team and incident specific narratives useful for team and host unit learning.** The chronology of key decisions provides IMT and Agency Administrator a quick reference for during incident discussions concerning alignment on priorities, strategies and tactics, and for after-assignment reflection during After Action Reviews. Beginning a KDL as soon as a unit recognizes the

incident may become large or of long duration (i.e., before a Type 1 or 2 team is ordered) creates a more comprehensive and useful document than a KDL covering only the time an off-unit team was present.

The still developing incident report that links incident intentions and objectives (from WFDSS) with key implementing decisions and actions allows the host unit-IMT partnership to reflect not only on the implementation process, but also on the quality and feasibility of the objectives.

Integration of Multiple Perspectives

One of the benefits of doing a joint research project with participants from different disciplines is the ability to integrate findings to tell a more comprehensive and nuanced story. Several common management implications emerged as the pieces of our individual efforts started to come together.

- 11. Cost is too narrow a focus when considering what factors should influence flexibility in fire management or for assessing fire management performance.** Numerous factors affect flexibility in fire management beyond cost, including agency-community interaction before and during the fire and cooperator concerns. Each of these factors must be taken into consideration in making fire management decisions and their interaction may increase or decrease the ability to implement less than full suppression strategies. Focusing on just one piece, such as decreasing cost, may lead to less effective decisions and implementation difficulties. A more effective approach is to assess fire management with a “balanced scorecard” approach using multiple metrics tailored to the fire objectives. For instance, low cost per acre may be a laudable goal for managing a fire for resource benefits and may be a cheaper way of meeting land management objectives than doing hazardous fuel treatments. However, if the objective is primarily protection, less aggressive strategies with a lower cost per acre or daily cost, but much larger acreages or longer duration, may lead to more costly fires and greater impacts on communities.
- 12. Taking a ‘balanced scorecard’ approach allowed us to integrate the multiple aspects of incident management into a single story, and understand the fire manager’s decision-making process in a way that sheds light on how to improve alignment with and achievement of incident objectives.**
- 13. A single point in time (during the fire) taking into consideration one participant group (federal land management agencies) is too narrow when considering how to manage fire more flexibly.** Pre-fire work with local communities and non-federal cooperators can influence the ability to manage more flexibly during a fire. Although the conventional wisdom is that the public expects and demands full suppression, our results indicated that the public is much more willing to accept less aggressive suppression strategies and longer-term events if good communication about the planned strategies and reasons for considering them occurs long before a fire begins. Pre-fire work also can help address non-federal cooperator concerns about the potential direct and indirect costs they believe they may incur from LTFS strategies.

Relationship to other recent findings and on-going work

Costs, Fire Manager and non-federal Cooperator Perspectives: Current economic work relates to a study published in 2007 - Estimating fire suppression expenditures on individual large wildland fires (Gebert et. al. 2007). The work on assessing stakeholder and cooperator perceptions relates to other studies looking at the factors influencing suppression costs, in particular: Canton-Thompson et al. 2006,

Canton-Thompson et al. 2008.

Agency-Community Interaction: This research built on a 2007 project with the Northern Research Station examining community response to Appropriate Management Response. In 2010 we will conduct surveys in three additional communities to continue to confirm or refute our findings from the 2008 interviews and the single 2009 survey. In addition, in Spring 2009, USFS Fire and Aviation Management asked the research team to initiate a complimentary effort to analyze the social networks at work within the host agencies and with the external communities to better understand how information flows and bottlenecks during a fire. This is being performed in conjunction with the already planned work to obtain more detailed information about information flows and how the public accesses information during fires. The combined results from the original two projects with the social networking analysis will provide in-depth detail and a more complete picture of the information and communication dynamics during wildfire events.

Organizational Performance: In 2009, a national science panel to develop operational performance measures for large wildland fire incidents was chartered by the Forest Service's Washington Office. Members of this JFSP project are participating:

- 1) to provide our progress to date on identifying and field-testing potential measures of ecological impact to the Science Panel; and
- 2) to determine whether the Key Decision Log and any of its products might be useful for providing data on non-quantitative objectives – the decision/risk management process and relationships with stakeholders and cooperators.

We are also working with the developers and managers of the WFDSS to integrate the KDL into WFDSS. Conceptually, the KDL complements the capture of strategic decision-making by focusing on incremental implementation decisions, and capture of other issues and actions having an impact on final fire outcomes. The KDL captures more information more consistently than WFDSS at this time, and the goal for 2010 will be to pull WFDSS decision text fields into the KDL to allow development of a full fire narrative.

Future work

Costs: The analyses of the effect of fire management strategies and costs left many unanswered questions and pointed out the need to assess fire management performance or success based upon multiple criteria. The results clearly showed that LTFS strategies can, in many instances, lead to total fire costs that are equal to or greater than direct suppression events. However, additional information is needed to assess the implications of these results. Some areas of further research might include:

- 1) Why are modified suppression fires so expensive compared to the other types? Is the fire complexity driving the selection of this strategy and, therefore, the costs, or is it simply a matter of longer duration and larger acreages?
- 2) Do less aggressive strategies equate to more beneficial fire effects? This could be accomplished by obtaining data for a larger sample of the metric identified here.
- 3) Does having more fire now equate to less fire, or less costly fires, in the future? The general assumption is that this is a true statement, but little research has been done to date on the temporal effects of fire suppression and costs.

- 4) How do differing strategies affect firefighter safety? Which is better, more exposure for a shorter period of time or less exposure for a longer period of time?

Agency-Community Interaction: In 2010 we will conduct surveys in three additional communities to continue to confirm or refute our findings from the 2008 interviews and the single 2009 survey. In addition, in Summer 2010, we will conduct complimentary studies on information flows through social networks on the same fires in which the surveys are implemented. The combined results from the original two projects with the social networking analysis will provide in-depth detail and a more complete picture of the information and communication dynamics during wildfire events.

Organizational Performance: In 2010, we will continue developing the Key Decision Log as a tool to assist with during-incident performance and as a means to understand and improve decision-making and performance at an organizational perspective. This latter includes additional analysis and development of the 'balanced scorecard' concept. Such an effort will benefit from close coordination with on-going efforts to develop better safety, operational efficiency, and ecological measures.

Considerable work remains to refine the KDL as a management tool, to provide outreach and training, and to rigorously analyze results.

KDL Development –

- 1) Refine the KDL application by additional work in the field during incidents and working with teams and host units to understand how to make more user-friendly and valuable.
- 2) Further development and testing of products such as the incident report that compares intentions with outcomes to produce a document that intuitively presents performance in a format and tone that facilitates learning (as opposed to evaluation). This would mostly working with Line to build their understanding of the utility, get feedback.
- 3) Further integrate with WFDSS to create transparency on user-side.
- 4) Identify the most valuable during- and post-season analysis (through meetings and discussions with all levels of line and fire staff) then develop canned procedures to batch-process KDL database and produce desired results.

KDL Outreach and training –

- 1) Develop and implement a communications plan to present KDL to NWCG for decision on interagency use.
- 2) Develop a webinar and other training and outreach materials

Balanced Scorecard/KDL research inquiry –

- 1) Continue to explore the growing database to assess its value as an 'expert learning database', and as a tool for capturing change.
- 2) Develop peer-reviewed publications and presentations to academic/scientific communities.

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APPENDIX A - Objective/Strategy Types and Definitions

Objectives

a) Protection: Objectives derived from land management direction to achieve protection of sensitive natural and cultural resources, facilities and values from negative effects through the exclusion of unwanted fire.

b) Resource benefit: Objectives derived from land management direction to achieve positive benefits from the presence of fire in a specific area. Benefits range across a wide scale from site specific to landscape and affect resources and community values.

Protection Strategy

1) Direct suppression – Strategy developed to achieve the minimum burned area. Would involve checking fire spread through direct perimeter control by line construction and use of fuel breaks and other barriers to fire spread that are immediately adjacent to active fire.

2) Modified suppression – Strategy developed to achieve control of a fire where fire is unwanted but minimizing burned area is not the primary goal. Unsafe conditions for firefighters, low values at risk, and/or concerns about total potential suppression costs influence specific tactics and foster use of perimeter confinement by both direct and indirect line construction and use of natural barriers and fuel breaks, both adjacent to active fire and some distance away from the fire. This strategy would result in use of a wider range of tactics than direct suppression.

3) Limited suppression – Strategy developed where conditions of the fire environment, resource availability, values at risk, and/or cost indicate this is the most effective strategy. These situations would involve the use of protection management by implementing more active monitoring and limiting suppression activities to those necessary to protect a specific point or specific area from fire, usually by directing the fire movement away from these areas or around these areas. This strategy would not result in a continuous control line around a fire.

Resource Benefit Strategy

1) Area monitoring: Strategy developed to achieve resource benefit objectives by allowing the fire to burn freely within the defined planning area with management attention focused on monitoring the fire.

2) Area management: Strategy developed to manage the fire to accomplish resource benefit objectives. Management actions consist of monitoring plus varying amounts and intensities of operational actions to delay, direct, or check fire spread to protect a defined area within the planning area or along the planning area perimeter. Actions taken depend upon the identified values at risk in and around the fire planning area and the natural defensibility of the planning area perimeter.

-Delaying actions prevent the fire from reaching values or the planning area perimeter at a certain time (although it may spread there later) or delay fire spread until the onset of a fire slowing or season ending event.

-Directing actions cause the fire to spread in a different direction, away from values of concern, or away from the planning area perimeter.

-Checking actions include line construction to stop fire from spreading to values or the planning area perimeter.