Influences to the Success of Fire Science Delivery: Perspectives of Potential Fire / Fuels Science Users

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Human Factors and Risk Management Research Development & Application (RD&A)

Partners:

USDA Forest Service,

- Human Factors and Risk Management RD&A
- Fire and Aviation Management
- National Fire Plan
- Pacific Northwest Research Station

USDI National Park Service, Fire Science and Ecology Program

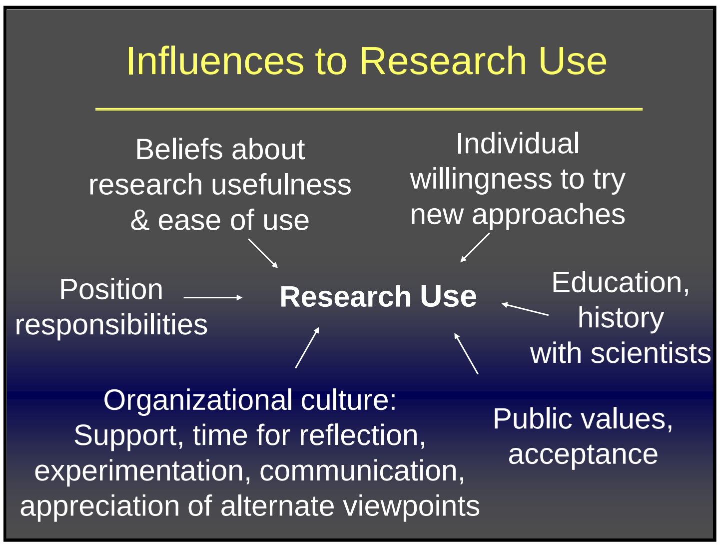
USDI Bureau of Land Management, Application of Science Program

National Center for Landscape Fire Analysis

Influences to the Success of Fire Science Delivery: Perspectives of Potential Fire / Fuels Science Users

Executive Summary

The 2001 Federal Wildland Fire Management Policy Review and Update (Guiding Principle #6) states, “Fire management plans and activities are based upon the best available science.” To date, the Joint Fire Science Program and National Fire Plan have invested approximately $300 million to improve the scientific foundation of fire and fuels management. The goals of fire policy and research programs can be achieved only if scientific products are effectively delivered to and applied by fire / fuels managers.



Guidance for achieving effective fire science application is limited. Based on a multidisciplinary literature review, partner agency meetings, interviews, and a written survey, this study gathered perspectives of potential fire and fuels science users in the USFS, NPS, and BLM; compared perspectives by pay grade, current position, agency, and education level; and developed recommendations for both scientists and managers interested in strategically improving the application of fire / fuels science.

Recommendations for Scientists

1. Expect a time lag to diffusion, even for relevant and consequential innovations.
2. Target delivery to early adopters, who can gain interest & support of peers: Fire Ecologists, Long-term Analysts, Regional / State staff & Master’s / PhD graduates.
3. Target delivery to positions responsible for research use and communication: especially mid- level (GS 9-11) Fuels Specialists, Fire Management Officers & Resource Specialists.
4. With managers, experiment with boundary spanner positions to facilitate application.
5. When it’s relevant, show research relevance (including models) to Fire Behavior Analysts.
6. Explicitly demonstrate objectivity, in both study design and communication.

Recommendations for Managers

1. Increase awareness of science policy mandates, especially for staff specialists.
2. Increase capacity for fuels specialists to apply and deliver science through increased exposure to scientists, educational opportunities, and formal recognition of these duties.
3. Recognize that lower-graded positions have different perceptions of information transfer, appreciation of differences, and opportunities for productive debate.
4. Cultivate learning environments that foster time for reflection, experimentation, information transfer, appreciation of differences, and productive debate for all grades.

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Abstract

The Joint Fire Science Program (JFSP) was established in 1998 to provide science-based support to fire and fuel treatment programs. A decade later, the 10-year JFSP program review noted that researchers were concerned that not all of their research results were being used by the field (JFSP 2009). Science application goals of the JFSP and other fire research programs can be achieved only if the resulting scientific information is effectively transferred to potential users.

Processes aimed at fire science delivery, application, and integration will be more effective if they are undertaken with an understanding of how social, psychological, and communication factors apply within the fire management community. Drawing on theories about human behavior, communication, and organizations, I surveyed federal fire / fuels managers and decision makers about their individual innovativeness, beliefs about research usefulness and ease of use, attitudes toward using research, relationship history with scientists, beliefs about scientists, organizational learning culture and processes, supervisor and agency support of science, and self reported research use. Survey results indicated the fire management community is comprised of subgroups with varying levels of receptivity to research. Respondents working as fire ecologists and/or long-term fire analysts, at higher grade levels, in centralized positions, in the National Park Service, and those with graduate degrees were more likely to be innovative, have positive beliefs and attitudes about research, and use research than respondents in other categories.

Organizationally, respondents working at higher pay grade levels had more positive perceptions than lower grade levels of the following organizational learning measures: psychological safety, openness to new ideas, appreciation of differences, analysis, and information transfer. Across grade levels, respondents slightly agreed they felt psychologically safe to introduce new ideas; however, respondents were neutral about whether different ideas were appreciated or likely to be analyzed. Of nine organizational learning measures, respondents across grade levels disagreed most that they had time for reflection.

When asked about 16 potential barriers to using research, 70% respondents agreed lack of time was a barrier. Barriers related to politics and public acceptance of science had the next highest agreement. Next, respondents agreed with organizational barriers such as lack of appreciation for innovation and lack of rewards for using research. Finally, respondents had the lowest agreement with research-related barriers. Of all barriers, they disagreed most with statements citing lack of relevant research, lack of knowledge of how to find research, and lack of knowledge about who to contact as barriers. When asked to agree-disagree that their agency was mandated by policy to use science, those working at higher grade levels, as line / staff officers, and / or as NPS employees reported less uncertainty about science policy mandates than other groups.

This study was the first comprehensive attempt to use social science theory and methods to understand and improve fire science application. The report summarizes key findings and provides recommendations to both scientists and managers interested in improving fire science application, and innovation in general.

Background and Purpose

Problem Overview

Faced with altered ecosystems, severe fire seasons, loss of structures in the wildland-urban interface, tragic firefighter fatalities, and exorbitant suppression costs, “resource managers are increasingly challenged by the need to justify decisions and apply scientifically sound solutions to complex problems” (USDAFS 2003). Furthermore, expectations from Congress and the public, such as those described in the Healthy Forest Initiative (HFI) and the Healthy Forests Restoration Act (HFRA), require managers to incorporate science into fire and fuels management under tight timeframes. The Joint Fire Science Program (JFSP) was established in 1998 to provide science-based support to land management agencies and to “expedite scientifically sound… solutions.” Complementing JFSP efforts, the National Fire Plan (NFP) was initiated in 2001 and provides research funding to support management of wildland fire and accelerate fuel reduction treatments.

Since their initiation, the JFSP and NFP have spent large amounts of money on fire and fuel research. From FY 1998-2007, the JFSP spent approximately $125 million on research to support fuel and fire management. From FY 2001-2007, the NFP spent approximately $182 million on research. The goals of these programs, as well as the HFI and the HFRA, can be achieved only if scientific products are effectively and efficiently transferred to the users.

To make relevant information available to fire and fuels managers, the JFSP has historically required that all proposals identify technology transfer actions. Many JFSP researchers propose to publish results, host information on web sites, and give presentations to management audiences. In addition, Federal agencies aim to improve awareness of and access to scientific information and tools by offering free publication distribution (e.g., USFS R&D Treesearch), library and document delivery services (e.g., Bureau of Land Management, Forest Service, National Park Service, and Fish and Wildlife Service Libraries), searchable web syntheses (e.g., RMRS Fire Effects Information System, SRS Forestry Encyclopedia Network), and training (e.g., National Advanced Fire Resource Institute).

Most of these approaches improve access for managers who actively search for scientific information. However, the use of science by broader communities of managers is dependent on more than information accessibility. For instance, established efforts to make information accessible do not generally address cultural and communication barriers (USDAFS 1997). Furthermore, there has been little formal strategic effort in either the fire community or other research and management communities to address fundamental barriers to effective research application. Strategic questions include: What happens once relevant science is “delivered?” Does availability automatically translate into awareness and use? If not, why not? Are there ways science can be delivered to achieve more effective application?

While technology transfer is most often the responsibility of research scientists, some USFS Research Work Units have hired dedicated technology transfer specialists (Berg 1997). Within the past decade, a number of new technology transfer and science delivery programs and/or positions have been created that address fire and fuels research (JFSP; BLM National Science and Technology Center's Division of Science Integration; USFS – PNW Focused Science Delivery Program, RMRS Wildland Fire Management Research, Development, and Application Program, RMRS Fire Modeling Institute, Southern Center for Wildland-Urban Interface Research and Information; and Wildland Fire Lessons Learned Center). However, there are relatively few precedents, guides, or proven methods to direct these programs on how to improve manager access to and use of scientific knowledge, and how to develop effective communications tools, techniques, and products.

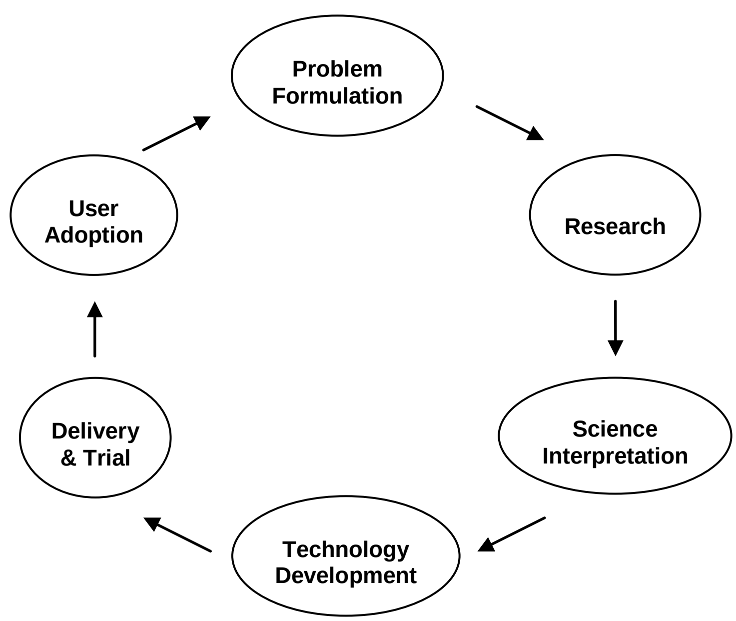
In addition to conducting science delivery by helping potential users find and understand relevant wilderness research, the Aldo Leopold Wilderness Research Institute's (Leopold Institute) Research Application Program (RAP) has spent the past eight years trying to understand the science application process (from awareness to use) and how to improve the effectiveness of science delivery. This effort has largely focused on understanding the perspectives of potential science users. In 2001, the Leopold Institute's RAP conducted a case study to explore how managers with diverse backgrounds and job duties access and use scientific information. Broader case study goals were to understand and improve the ability of federal land managers to access and use relevant scientific information. In addition, while emphasizing wilderness fire, invasive species, and recreation management, the Leopold Institute planned to use case study results to prioritize wilderness research application efforts. During January and February 2001, Leopold Institute RAP staff interviewed 13 managers with wilderness fire, invasive plant, or recreation responsibilities, using a U.S. Forest Service wilderness as a case study. Interviewees responsible for the case study wilderness ranged from local resource staff specialists, wilderness specialists, and decision makers to centralized staff specialists. Interviewers gathered information about job roles and responsibilities, methods used by managers to access science, how managers use science, barriers to accessing and using science, and suggestions for overcoming barriers (Kearns and Wright 2002).

Following the case study, the Joint Fire Science Program took the lead in funding the project described in this report, which incorporated social science expertise into the effort to understand science delivery and fire science audiences. There is a wealth of scientific knowledge on individual and organizational communication, human behavior, and social relationships that can provide insight into how target audiences respond to new scientific information and tools; however, this literature is dispersed through a variety of social science disciplines and has not been integrated effectively into the management of fire or other natural resource disciplines. Processes aimed at fire science delivery, application, and integration will be more effective if they are undertaken with an understanding of how social, psychological, learning, and communication factors apply to different potential user groups in the fire management agencies. If the costs of research are to be fully recovered, it is critical that the wildland fire science and management communities understand how research products are communicated as well as the factors that influence when managers integrate new information into existing practices.

Integration with Other Recent Efforts to Understand Science Delivery

The USDA Forest Service, in particular has periodically attempted to strategically address issues of technology transfer and science application. The State and Private Forestry (S&PF) branch hosted a technology transfer and application group in the 1970's, and in 1994 the Deputy Chiefs for Research and Development (R&D) and the National Forest System (NFS) sponsored a Forest Service Roundtable on science-policy integration (USDA Forest Service 1995). More recently, in 2004, the R&D, S&PF, and NFS Deputy Chiefs formed an interdeputy team to evaluate the agency's science technology and application efforts. Though it was never implemented, this team drafted a plan of action for improving the delivery and application of science-based technology in support of the Forest Service's mission. The plan defined science and technology application as a "cycle" of activities (Figure 1).

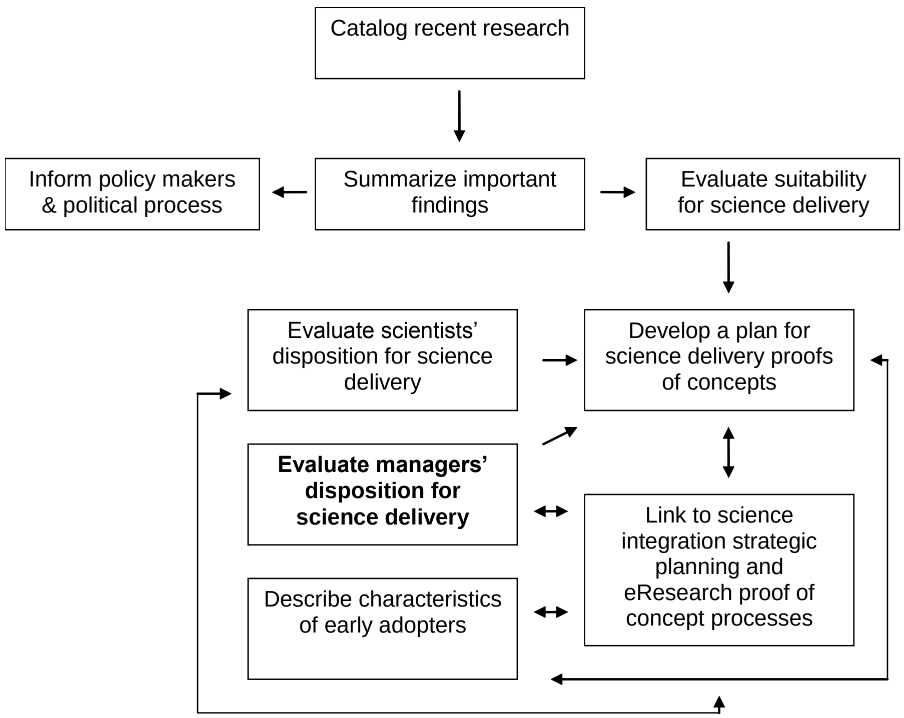
Figure 1. Science Application Cycle [Adapted from USDAFS 2004].



The agency's Rocky Mountain Research Station has used this cycle to provide context for their recent development of a Science Application and Integration Program. The research reported here focuses on the delivery and user adoption parts of the cycle, by striving to understand influences to the adoption of wildland fire and fuels research among different potential user groups.

Based on the Joint Fire Science Program's high level of interest in facilitating successful science delivery, the program initially funded two projects focused on understanding the fire science adoption process (Project #s: 04-4-2-01 and 05-S-07). The final report for Project 05-S-07, presented a conceptual model to help accelerate adoption (Barbour 2007). The research reported here (Project 04-4-2-01) fits within a third box added to the lower half of the model labeled "Evaluate managers' dispositions for science delivery" at the individual and organizational levels (Figure 2).

Figure 2. Conceptual model to accelerate adoption of fire sciences [Adapted from Barbour 2007, with box added (bold) to include this study's emphasis].



Project Objectives

This study used social science research theory and methods to investigate individual and organizational influences to the use of science for fire and fuels management in the National Park Service, Bureau of Land Management, and United States Forest Service. Specific study objectives were to:

1) identify and understand barriers to effective delivery and application of scientific knowledge for fire planning and fire risk assessment at various levels within federal agencies, and

2) develop recommendations that can be used strategically by researchers, science application specialists, and managers to increase the effectiveness and efficiency of science delivery.

Study Description

Multi-Method Approach

This study was implemented in the following three steps:

Step 1: Conducted a literature review and agency partner meetings to identify influences to effective delivery and use of science.

Step 2: Conducted in-depth interviews to understand influences within the context of different agencies, organizational units, and positions.

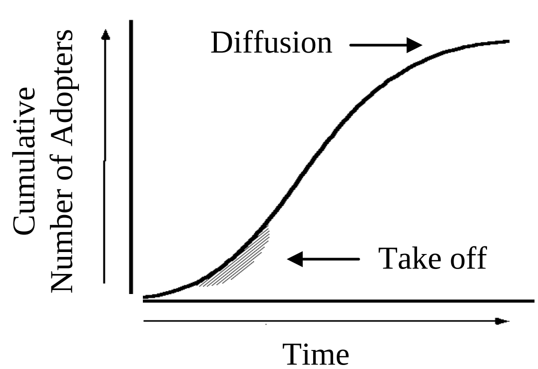
Step 3: Conducted a questionnaire-based quantitative survey to compare the perspectives of different groups within the broader population of fire / fuels managers and decision makers.

Step 1a. Literature Review: Social Science Theory Important for Understanding Science Delivery

Diffusion of Innovations

The *Diffusion of Innovations* theory explains that adoption of new ideas and approaches is a multi-stage process with the potential for active or passive rejection at several points during the innovation-decision process. The decision to try an innovation is contingent on a potential user developing an interest, understanding, and positive attitude toward the innovation. This theory recognizes that diffusion through a community, when most individuals have adopted an innovation, takes time. The rate of adoption is seen in an S-curve (Figure 3), where the initial rate of adoption is slow. Then, for innovations where diffusion is successful, the rate of adoption increases as information about the innovation passes through communication networks and more individuals adopt the innovation. Finally, the rate slows again after diffusion through most of the community has occurred (Rogers 2003; Wright 2004).

Figure 3. S-shaped adoption curve, representing an increased rate of adoption from the point of take-off to successful diffusion (Rogers 2003).



This overarching theory, often used to understand or facilitate social change, recognizes that it takes time for individuals, and communities, to incorporate innovative concepts and techniques into established practices. The amount of time depends on individual characteristics of the potential adopters, social norms (i.e., values and expectations within peer groups), and communication networks. The project described here attempted to understand individual and organizational characteristics of potential fire and fuels research users based on the premise that science communicators will be more effective if they understand research-related perspectives of different audiences within the fire management community.

Communication

Communication is fundamental to how individuals navigate through the innovation-decision process. Through communication, managers acquire information that increases their awareness of and ability to evaluate scientific products. However, communication research reveals that the potential for misunderstanding during communication is high. Scientists and managers can misunderstand each other as a result of language ambiguity, inadvertent secondary messages, selective attention to conserve cognitive resources, inferences about a speaker's goals, long-established perceptions, and a tendency to interpret information so it is congruent with existing beliefs and attitudes (Sillars and Vangelisti 2006; Wright 2007).

The Diffusion of Innovations theory notes that individuals are most likely to interact with others who they perceive to hold similar personal and social characteristics (e.g., personal or cultural beliefs, education, work experience). Communication among such individuals, described as homophilous, is more comfortable and more effective because these individuals share common meanings and subcultural language. In contrast, heterophilous individuals are perceived to be different (Rogers 2003). With different backgrounds and priorities, research scientists and managers are often heterophilous. According to Rogers (2003), communication among heterophilous individuals can be problematic when it causes internal conflict for potential adopters who find messages to be inconsistent with their beliefs and established methods. These differences can lead to misunderstandings. Furthermore, uncertainty about each other's beliefs and goals can make it difficult to communicate messages effectively (Berger 1997).

The communication discipline has long recognized that "the effects of a communication are partly dependent upon the characteristics of individual members of the audience," including both personality predispositions and group affiliations, and that knowledge of individual predispositions can be used to predict the way a given type of audience will respond to communicated messages (Hovland et al 1953). This project provides a better understanding of potential fire / fuels science users' individual predispositions toward new ideas as well as beliefs and attitudes about research and scientists. Senge (1990) refers to such underlying beliefs and attitudes as "mental models" that influence "what we see" and, thus, "what we do." Research communicators will be able use knowledge of managers' predispositions to predict audience receptivity to new ideas and to tailor messages to specific audiences, thus reducing misunderstanding and shortening the time to diffusion (Berger 1997; Wright 2007).

Individual Beliefs and Attitudes

During the second stage of the innovation-decision process, individuals weigh the advantages and disadvantages of the innovation compared to current approaches. This leads to either a favorable or an unfavorable attitude toward the innovation (Rogers 2003). This part of the Diffusion of Innovations theory is compatible with the Theory of Reasoned Action, which purports that an individual's behavior (e.g., a decision to use a scientific innovation) is influenced by the interaction of an individual's attitude, social norms, and the perception that their behavior will achieve the desired outcome (Ajzen and Fishbein 1980). Individual "beliefs" refer to the thoughts, ideas, feelings, or emotions that represent both the cognitive and affective [feeling] aspects of attitudes (Eagley and Chaiken 1993). Beliefs can be toward people (e.g., scientists), objects (e.g., specific research), and issues (e.g., management issues). Rogers (2003) predicts that the affective component of attitudes influences whether individuals decide to adopt innovations. This project measured individual beliefs and attitudes, about using research and working with scientists, which are likely to influence how quickly potential fire / fuels science users adopt innovations.

Individual Personality

The Diffusion of Innovations theory classifies individuals according to their comfort with uncertainty and how willing they are to adopt new ideas. People are classified into the following groups: innovators, early adopters, early majority, late majority, and laggards. These terms describe differences along a continuum of comfort levels. According to the theory, managers who are comfortable with a high degree of uncertainty will adopt innovations faster than those who are uncomfortable with uncertainty. This project measured the personality trait of individual innovativeness, or willingness to change, to determine whether certain groups of potential fire / fuels science users are comprised of individuals who are more or less likely, given similar situations, to adopt innovations than other groups.

Personality refers to the general psychological dispositions of individuals, such as their comfort with uncertainty, that influence patterns of behavior. The influence of personality has long been a controversial topic (Bandura 1986, Daly 2002). Some argue that for a personality trait to serve as a useful explanatory concept, behaviors associated with that trait should have cross-situational consistency; others argue that behaviors result from a combination of personality and situation. Still others propose models where people gravitate toward situations that are compatible with their personalities. Personality, especially regarding comfort with uncertainty, is part of the individual context that influences the communication and adoption of scientific innovations by land managers. However, the relevance of personality traits may vary across individuals, and the expression of personality traits are likely to be influenced by social and organizational contexts (Daly 2002). Therefore, this project also measured contextual or organizational influences to the adoption of fire / fuels innovations.

Organizational Culture

According to Wilson (1989), "Culture is to an organization what personality is to an individual." Culture includes shared values, beliefs, assumptions, perceptions, norms, artifacts, and patterns of behavior that provide meaning and direction to organizational members (Ott 1989, Weick and Sutcliffe 2001). Organizational theorists acknowledge that people need culture for "identity, purpose, belonging, communication, stability, and cognitive efficiency" (Ott 1989). From this perspective, people behave based on cultural norms, values, beliefs, and assumptions more than they follow formal rules (Weick and Sutcliffe 2001, Ott 1989). This project measured perceptions of organizational culture regarding innovation and support for using science within each of the three agencies, BLM, NPS, and USFS.

Innovation

Thompson (1965) defined innovation as "the generation, acceptance, and implementation of new ideas, processes, products or services." This encompasses most definitions of innovation, with some emphasizing creativity and idea generation and others emphasizing implementation. This study focused on the implementation of existing fire / fuels innovations developed through research, which are either new or perceived as new.

The Diffusion of Innovations theory recognizes that system norms (i.e., peer-driven standards or rules that guide what people are expected to think, say, or do in specific situations) can influence the use of innovations. Similarly, organizational theorists have long recognized the influence of organizational structure and culture when querying what makes an organization innovative (Aiken and Hage 1971, Zaltman et al. 1973). The assumption is that "organizational variables act on innovation behavior in a manner over and above that of the aggregate of individual members of the organization" (Rogers 2003).

Learning

Garvin (2000) and Weick and Sutcliffe (2001) describe an organizational culture necessary for adoption, one that provides a learning environment where individuals are encouraged to meet organizational goals through being innovative and mindful. Rather than compiling evidence of existing, taken-for-granted, beliefs, learning environments are characterized by attention to anomalies, inquiry, and updating of practices (Weick and Sutcliffe 2001). Garvin (2000) notes that, in addition to acquiring information, it must be interpreted and applied to modify behavior. These authors all recognize that dissenting opinions are not only acceptable in a learning organization, but they are valued. Thus, in order for adoption of scientific knowledge and tools to occur, individuals must function within a culture that allows for, and even rewards, innovation. In addition to overall organizational culture, Garvin et al (2008) suggest that organizational culture of the work unit can influence behavior. This project assessed organizational characteristics identified by Garvin et al that either contribute to or hinder a learning environment. Such analysis can help upper-level managers interested in creating and/or maintaining a learning environment understand their work unit's strengths and weaknesses.

Integrating Individual and Social Contexts

Since the expression of individual traits, such as attitude and personality, may be socially influenced (Daly 2002), Eisenberg and Goodall (2001) note that individuals within organizations must balance individual creativity against organizational constraints. As noted earlier, the Theory of Reasoned Action purports that an individual's behavior (e.g., a decision to use a scientific innovation) is influenced by the interaction of an individual's attitude, social norms, and the perception that their behavior will achieve the desired outcome (Ajzen and Fishbein 1980). This is compatible with theories from the social psychology and communication disciplines, which acknowledge that communication effectiveness is influenced by group membership and adherence the group's norms (Hovland et al. 1953). In fact, Rogers (2003) asserts that "in almost all cases, centering on individual-level variables is not a complete explanation of the diffusion behavior being investigated." As such, the adoption of scientific innovations may be a context-specific phenomenon, where the interplay between individual and organizational influences ultimately drives the effectiveness of communication and the decision to use scientific innovations.

This project aimed to understand both individual and social contexts surrounding innovation decisions about fire / fuels science. Individual contexts included personality, beliefs, and attitudes. Social contexts were measured for the entire agency and the work unit. Understanding how individuals balance personalities and beliefs about science with organizational norms is critical to understanding the outcome of communication about fire / fuels science.

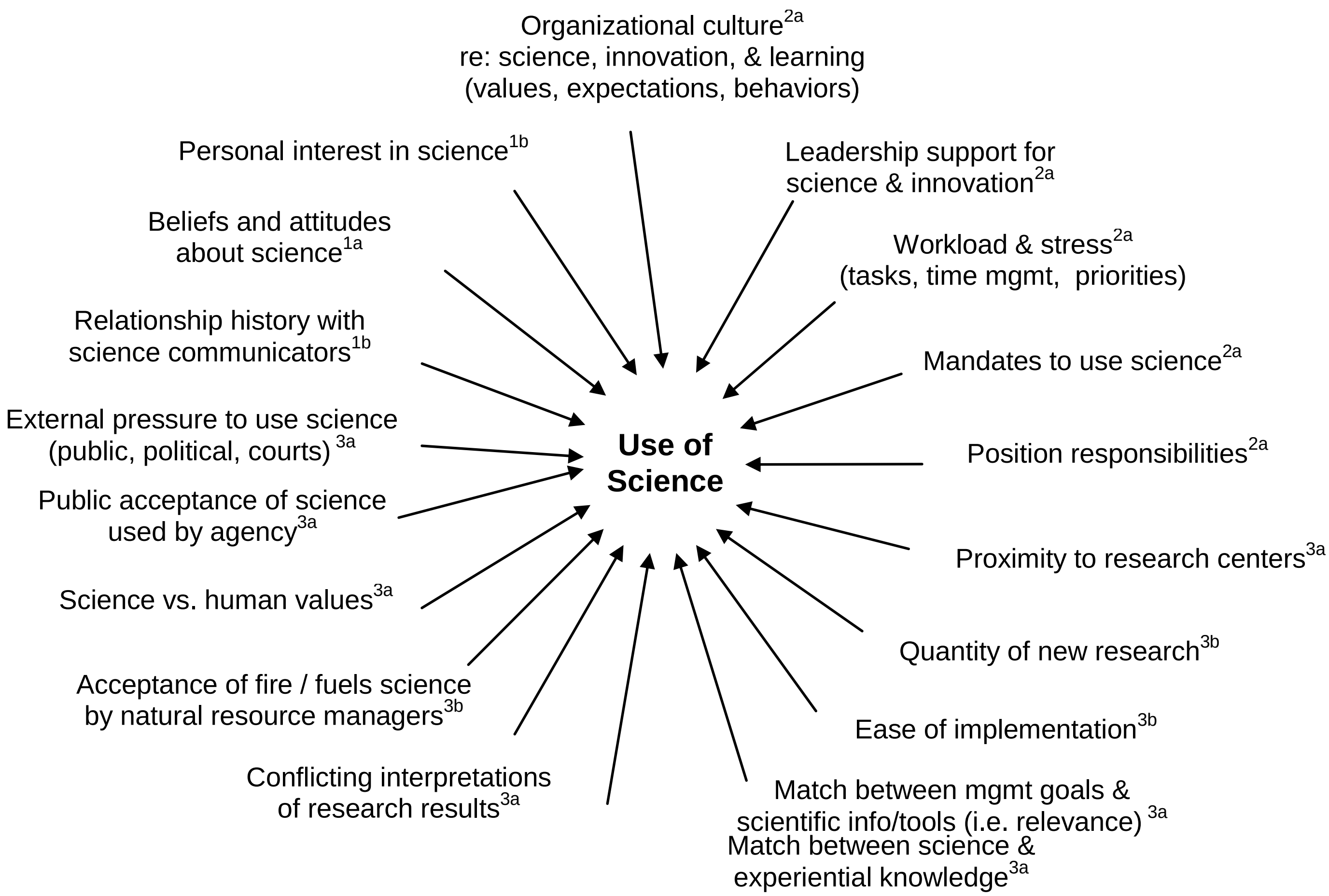
Step 1b. Agency Partner Meetings

Following the literature review, four agency meetings were organized to collect additional ideas about the range of potential influences to the communication and application of science within the context of each agency's social system. Feedback obtained during these meetings was used to develop themes for the interviews and, subsequently, the surveys. The meetings were held with BLM natural resource specialists and managers (Denver, CO; January 2005), an interagency (USFS, NPS, BLM) group of fire and fuels managers (Jacksonville, FL; February 2005); USFS fire and fuels managers and researchers (Albuquerque, NM; March 2005); and NPS natural resource specialists and managers (Philadelphia, PA; April 2005) (Wright 2006).

Participants in the four agency partner meetings identified a range of individual, organizational, and external influences to the use of research for management (Figure

4). Individual influences included personal interest in science; beliefs and perceptions about science; relationship history with science communicators; and individual learning styles. Organizational influences included position responsibilities; workload and stress; organizational cultures regarding science, innovation, and learning; leadership support for science and innovation; and mandates to use science. External political influences included external pressure on the organization to use science; public acceptance of the science used by the organization; and science versus human values. Finally, external research-related influences included conflicting interpretations of research results; the match between management goals and scientific information or tools; the match between research results and experiential knowledge; ease of implementation; proximity of organization to research centers; and the quantity of new research. Results of the NPS agency partner meeting were published in Wright (2006).

Figure 4. Influences to the use of science identified during literature review and agency partner meetings. All influences were explored during in-depth interviews. Superscripts denote whether influences were explored in the survey.



[1]individual influence, [2]organizational influence, [3]external (public, research) influence
[a]addressed in the survey, [b]not addressed in the survey

Step 2. In-depth Interviews

Within the contexts of the three agencies (USFS, BLM, and NPS), regional case studies were selected to determine how factors identified during the literature review and agency meetings, as well as unanticipated factors raised during interviews, were relevant to the communication and application of science within the different agency contexts.

Each of the three management agencies provided one regional case study. Within each agency “case study,” we selected one centralized “study site” (e.g., NPS Regional Office) and two local “study sites” (e.g., National Parks). At each study site, interviews were conducted with line officers (e.g, USFS District Ranger, Forest Supervisor, BLM Manager, NPS Superintendent), staff officers (e.g., Program Managers, such as NPS Division Chiefs) who are most involved in day-to-day decisions related to fire and fuels management, and the fire staff specialists (e.g., fire management officer, fuels specialist, fire ecologist). In situations where the position was vacant or the incumbent had been in the position less than two years, an interview was requested with the person who previously held the position. For the three agencies, this totaled to 49 in-depth interviews, including 24 local fire staff specialists, 15 local decision makers and assistant decision makers, 11 central fire staff specialists, and 4 centralized assistant decision makers.

The interview guide was developed based on knowledge gained from a pilot study (Kearns and Wright 2002), the literature review, and the agency partner meetings. Themes covered included the role of research, limits of science, individual decision processes (including comfort with uncertainty, how individuals weigh scientific with experiential knowledge, how they deal with scientific uncertainty, how they reconcile conflicting research), history with and perceptions of science and scientists, organizational cultures regarding science and innovation, communication networks, and public influences to the use of science. An open-ended interviewing approach provided flexibility to probe and clarify ambiguities in respondents’ answers, and to discover unanticipated factors that are unique to the context of each case study (Patterson and Williams 2001). However, an interview guide was used to ensure that interviews were systematic and focused and that responses were comparable across interviews.

For the purposes of this report, the interviews were used primarily as an elicitation study for survey development. When designing surveys, it can be challenging to generate questions that are relevant to the population being studied. Often survey questions are developed based on the researcher’s preconceived perception about what the salient issues may be. However, researchers may not fully understand the context or environment in which the respondents they are studying operate. The best approach to addressing this challenge, especially for complex phenomena, is to conduct an elicitation study in which open-ended conversations with members of the population of interest are conducted prior to the survey. This helps identify perceptions of the study population and other salient factors that should be incorporated into the design of the survey.

Step 3. Questionnaire-based Survey

Survey Goals

The survey was used to compare perspectives of different groups of potential fire / fuels research users on individual, organizational, and external influences to the use of research that were identified during the earlier phases of the study. This survey focused on understanding differences among groups within the fire / fuels management community, with groups defined as different agencies, different pay grade levels, administrative levels, positions, and fire assignments. Detailed methods and results are reported in Wright (In Prep).

Sampling Frame

Population

The study's target population was professional fire specialists, fuels specialists, and decision makers responsible for fire / fuels planning and implementation in the USFS, NPS, and BLM. This population is a subset of the group of research consumers described in the JFSP science integration strategy. The JFSP strategy defines consumers as "GS-7 to GS-15 specialists and line officers who plan and implement activities associated with wildfire and natural resource management on federally-administered land, and their counterparts who manage state and private lands." The JFSP definition is broader in that it includes other federal resource management specialists as well as managers of other federal, state, and private land management agencies.

For this study, education, prevention, mitigation, dispatch, and purely operational or production-oriented positions were excluded from the population because these positions are not generally focused on fire / fuels planning and implementation. The USFS, NPS, and BLM were selected as the three agencies that would yield large enough sample sizes to compare survey responses by agency.

Survey Distribution

Based on the independent recommendations of a recent USFS Regional Fire Director, an NPS National Fire Ecologist, and a BLM State Fire Management Officer, the survey was distributed via 45 regional / state meetings and training courses where there would be concentrations of the target positions: line officers (e.g, USFS District Ranger, Forest Supervisor, BLM Manager, NPS Superintendent), staff officers (e.g., Program Managers, such as NPS Division Chiefs) who are most involved in day-to-day decisions related to fire and fuels management, and the fire staff specialists (e.g., fire management officer, fuels specialist, fire ecologist). Most of these meetings occurred in the western United States, including NPS Intermountain and Pacific West regions; USFS regions 1, 2, 3, 4, 5, and 6; and the corresponding BLM states. However, some meeting attendees who completed the survey worked in the eastern and Midwestern regions of the country. Though implementation was cumbersome, this survey distribution method was intended to 1) increase total number of surveys completed by the target population, and 2) reduce potential response bias favoring completion by those who tend to use research more than others.

Sample Characteristics

This section describes the diversity of respondents who received and completed the questionnaire, including agency, geographic region, administrative level, pay grade level, education, tenure, and gender. Survey respondents were administratively and geographically diverse with the following notable exceptions: poor representation from Alaska, national level positions for all agencies, line officers at the state / regional level for all agencies, and NPS Park Superintendents.

A total of 579 surveys were completed by members of the target population. The agency composition was 63% USFS, 22% NPS, and 15% BLM.

Geographic representation was diverse within the Western United States. Fifty-six percent of the respondents were from states and regions within the NPS Intermountain Region, which includes the USFS Intermountain, Northern, Rocky Mountain, and Southwest Regions. Thirty-five percent were from states and regions within the NPS Pacific West Region, including the USFS Pacific Northwest and Pacific Southwest Regions. One percent was from Alaska. The remaining 8% were from states and regions within the NPS Eastern and Midwestern Regions.

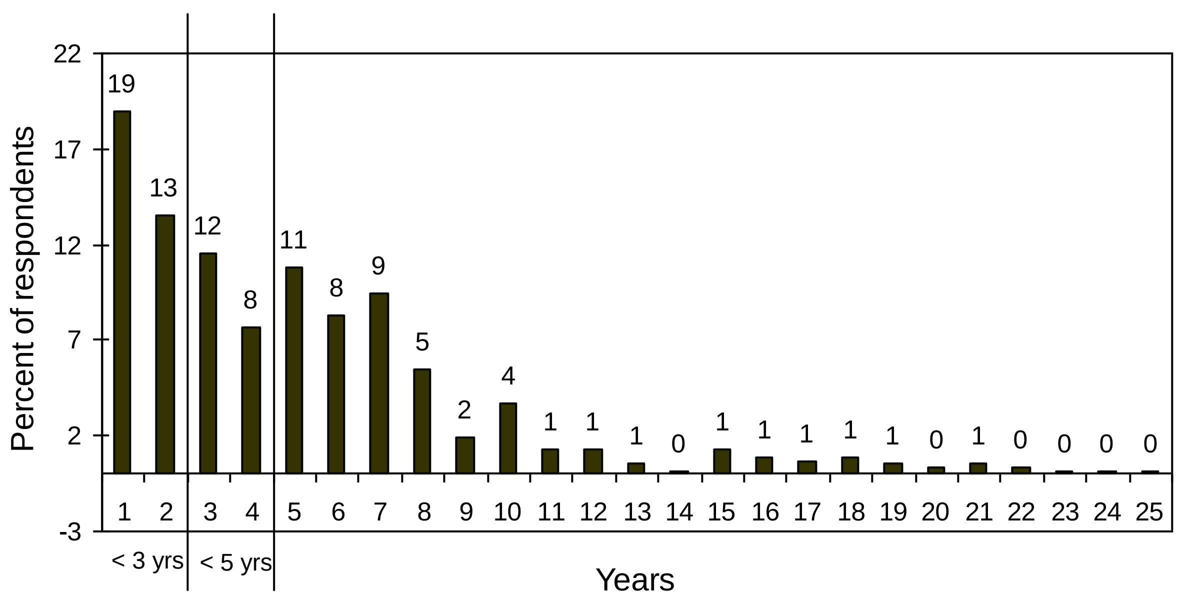
Most of the surveys were completed by individuals in local level positions; 88% of the BLM surveys were from local district and field office positions, 77% of the NPS surveys were from local park positions, and 96% of the USFS surveys were from local forest and district office positions. The NPS had proportionately more surveys completed by regional office positions (18% of NPS surveys) than the BLM and USFS, which were completed by 9% and 4% of their agency surveys, respectively. The NPS also had the greatest percentage of national positions (6% of the NPS surveys), compared to 0% of the USFS surveys and 3% of BLM surveys. Based on the survey distribution method, national level perspectives were virtually unrepresented by the survey.

Most (87%) surveys were completed by individuals working at “professional” pay grades (GS-9 to GS-13) as determined by the Office of Personnel Management (OPM). Of the 42 surveys completed by individuals at the GS-14 and GS-15 levels, most (69%) were completed by USFS Forest Supervisors and Deputy Forest Supervisors. An additional 12% were completed by BLM District or Field Office Managers, 7% were completed by NPS Park Superintendents, 10% were completed by NPS National and Regional Fire / Fuels Specialists, and 2% were completed by the USFS National Fire / Fuels Specialists.

The GS-7 and GS-8 positions are considered by OPM as non- or pre-professional pay grades. Some individuals working at these grade levels operate as fire and fuels specialists responsible for fire / fuels planning and implementation, either on smaller administrative units or as assistants on larger units, and others operate in operational or production-oriented positions but are interested in, or training for, professional fire / fuels planning and implementation positions. Based on the meetings where the survey was distributed, and the positions listed by those who completed surveys by these grade levels, most of the GS-7 and GS-8 surveys included in the analysis represent these two categories. Of the 69 surveys completed by individuals at the GS-7 and GS-8 levels, 28% (19) identified themselves as fuels specialists, 7% (5) as AFMOs, 14% (10) as operations specialists, and the remaining 51% (35) listed themselves as the following "other position": 11 engine supervisors/crew, 9 fire use module members, 5 fuels technicians, 3 fire effects positions, 3 forestry technicians, 1 smokejumper, 1 hotshot superintendent, I captain, and 1 helitack. The median percent of responsibilities that involved fire / fuels planning by respondents in this grade level who provided data (n=58) was 45%, which means that half of the GS 7-8 respondents spent more than 45% of their responsibilities involved in fire / fuels planning.

Tenure results were similar across agency and position. Overall, fire / fuels specialists and decision makers in the BLM, NPS, and USFS who responded reflected an experienced workforce. The mean number of years worked in fire / fuels management ranged from 17 years (NPS) to 19 years (BLM) with a maximum number of years worked in fire ranging from 34 years (BLM) to 39 years (USFS). In contrast to the time worked in fire / fuels management, or in their agency, respondents demonstrated frequent movement among positions. Half (52%) of the respondents had been in their positions less than 5 years, and approximately one-third of them (32%) had been in their positions less than 3 years (Figure 5). These numbers were similar for both line / staff officers and specialists.

Figure 5: Number of survey respondents by *years worked in current position* (n=564).



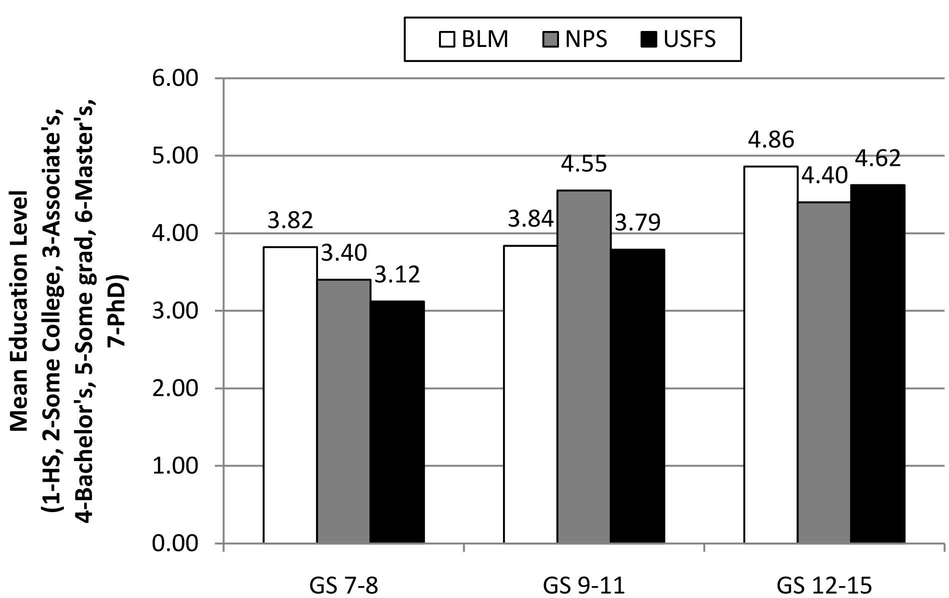
The education level of respondents varied, with the NPS and BLM showing higher average education levels than the USFS (Table 1). To see whether this trend held across grade levels, the mean education level of three pay grade categories (GS 7-8, GS 9-11, and GS 12-15) was compared. For the GS 7-8 and GS 12-15 pay grade categories, there was no significant difference in mean education level across agencies. However, for the GS 9-11 category, the mean education level in the NPS averaged between a Bachelor's and a Master's degree, whereas the GS 9-11 BLM and USFS respondents averaged just below a Bachelor's degree. The GS 7-8 grade level also averaged lower than a Bachelor's degree. At the GS 12-15 levels, the mean education level for all agencies was greater than a Bachelor's degree, indicating a greater occurrence of graduate education at these grade levels (Figure 6).

Table 1: Percent of survey respondents with the *highest education level*, *mean education level*, and *mean year of latest degree* within each agency.

Education Level	BLM	NPS	USFS	All
High School	0	1	2	2
Some college	12	8	16	13
Associate's degree	5	3	10	8
Bachelor's degree	44	54	40	44
Some graduate school	16	14	15	15
Master's degree	24	17	16	17
Doctoral degree	0	2	1	1
N	87	125	357	569
Mean education level	4.37	4.34	4.02	4.14
Sd education level	1.231	1.164	1.349	1.300
Mean year of latest degree	1989	1989	1989	1989

1 – High School, 2 – Some college, 3 – Associate's degree, 4 – Bachelor's degree, 5 – Some graduate school, 6 – Master's degree, 7 - PhD

Figure 6: Mean *education level* for grade level categories GS 7-8 (n=69), GS 9-11 (n=256), and GS 12-15 (n=237), by agency.



Most (77%) of the survey respondents were male. However, almost one-quarter (23%) of the surveys were completed by females. Percentages of males and females were the same across agencies; however, they differed for all other group comparisons. Female respondents worked at higher pay grades and had higher education levels than male respondents. Females also had higher percentages of line / staff officers and fire ecologists than males, who had higher percentages of fire management officers / assistant fire management officers and operations specialists.

Key Findings / Discussion

Understanding Audiences

"Any interpretation that does not somehow relate what is being displayed or described to something within the personality or experience of the [listener] will be sterile."

-- Freeman Tilden.1957. Interpreting Our Heritage.

Scientists primarily disseminate research results by giving formal or informal presentations and writing publications. Knowing the intended audience is one of the foundational rules of both public speaking and persuasive writing. Yet, how well do most public land research scientists and science communicators know their audiences? This study was primarily an effort to understand the perspectives of fire / fuels specialists and decision makers about research and, more generally, science, so that their perspectives can be taken into account by science communicators. Understanding the perspectives of potential fire / fuels science users can facilitate "targeting," which Rogers (2003) describes as "the process of customizing the design and delivery of a communication program based on the characteristics of an intended audience."

Conclusions in this report are based on social science literature on communication, human behavior, and organizational theory; agency meetings; in-depth interviews and a questionnaire survey. Differences were found for individual innovativeness (willingness to try new things), relationship history with scientists, attitudes and beliefs about using research, perceptions of organizational culture, processes for learning, and leadership support for innovation. Differences occurred by agency, pay grade level, administrative level, current position, fire assignment, and educational background. This section discusses the relevance of those findings for the dissemination and adoption of innovations for fire / fuels management. If research results are proactively disseminated within environments that are conducive to innovation, more effective science delivery can shorten the time lags that are inherent in the diffusion of innovations.

Fire Management Subgroups: Differing Perspectives on Research Use

This study shows that, rather than a single community with similar perceptions, the fire / fuels management community is comprised of subgroups with differing perceptions relevant to research use. Knowledge of these subgroups will help science communicators better understand, and tailor messages to, their audiences. It will also help upper level managers interested in promoting science application identify strengths and weaknesses within their programs.

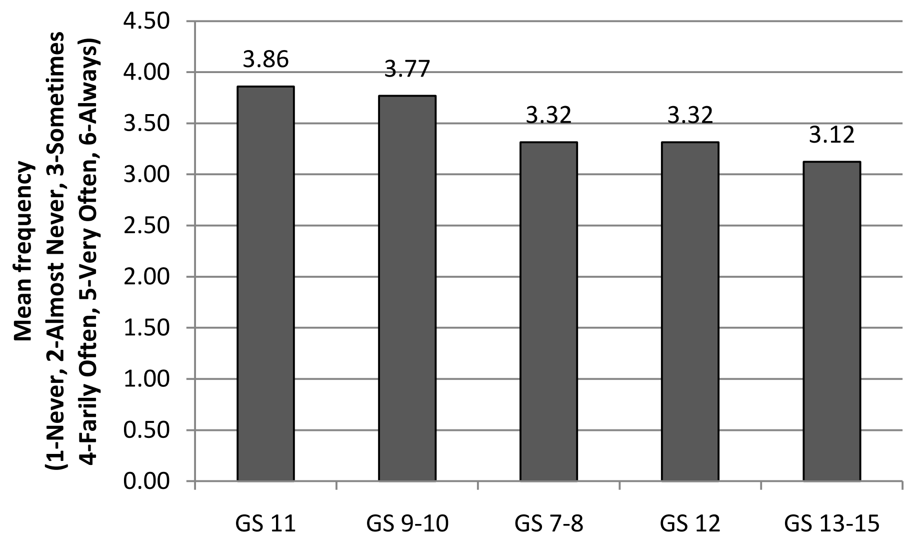
Based on responses to the *individual innovativeness*, *relationship history with scientists*, *beliefs and attitudes about research*, and *research use / promotion* measures, the following subgroups are likely to be most receptive to messages about scientific innovations: NPS employees, employees working in state or regional offices (also national offices, but the sample size (9/495) was small), line / staff officers, fire ecologists, long-term fire analysts, and individuals with graduate degrees.

Perspectives of these groups are not surprising. Those working in centralized offices and / or in line / staff positions, based on greater exposure to science, would be expected to have the broadest perspectives on management and the role science plays in meeting objectives. Fire ecologists and long-term fire analysts would be expected to have the greatest familiarity with science, since these positions depend on science for a greater portion of their responsibilities than other positions and fire assignments. Those with graduate degrees have spent more time studying science and conducting research than those without graduate degrees. Possible reasons for agency differences are discussed in the agency science culture section.

> *"When I got to be a district ranger, I probably had more appreciation for and valued that kind of scientific input and the kind of information you could get from scientists and science publications than I did previously. And in my current job, I have a much, much higher level of appreciation for what science gives us than I probably ever had in any previous job."*
>
> *--USFS Centralized Line Officer*

Although grade level was not significant for the *relationship history with scientists*, *beliefs and attitudes about research*, or *research use / promotion* measures, it was significant for the *searching for / reading / evaluating research* measure. Respondents in the GS 9-11 categories scored significantly higher than all other pay grades for searching for / reading / evaluating research. GS 9-11 respondents, on average, indicated they search for / read / evaluate research "fairly often," whereas GS 7-8 and GS 12-15 respondents indicated they do so "sometimes" (Figure 7). This is not surprising, as positions at these levels are most often responsible for analyzing management options and making recommendations to line / staff officers. For example, respondents at the GS 9-11 pay grade levels were comprised of 96% fire / fuels specialists and only 4% line / staff officers. This is compared to the GS 12-15 pay grade levels, which were half (51%) line / staff officers and half (49%) fire / fuels specialists. At the GS 12-15 levels, over one-third (39%) of the fire / fuels specialists worked in Regional / State / National Offices and none worked in local BLM or USFS offices. Therefore, with the exception of the NPS, even the specialists at these higher grade levels are likely to rely on more local, lower graded positions to search for, read, and evaluate research. At the other end of the spectrum, the GS 7-8 levels would not be expected to search for, read, and evaluate research as often because they were primarily in operational positions: 14% were operations specialists and 51% listed themselves as the following "other position": 11 engine supervisors / crew, 9 fire use module members, 5 fuels technicians, 3 fire effects positions, 3 forestry technicians, 1 smokejumper, 1 hotshot superintendent, 1 captain, and 1 helitack. Though they use research "sometimes," these positions would be less likely than GS 9-11 positions to search for, read, and evaluate research as a large part of their work responsibilities.

Figure 7: Mean frequency of *searching for / reading / evaluating research*, by grade level (n=495).



Relationships with Scientists

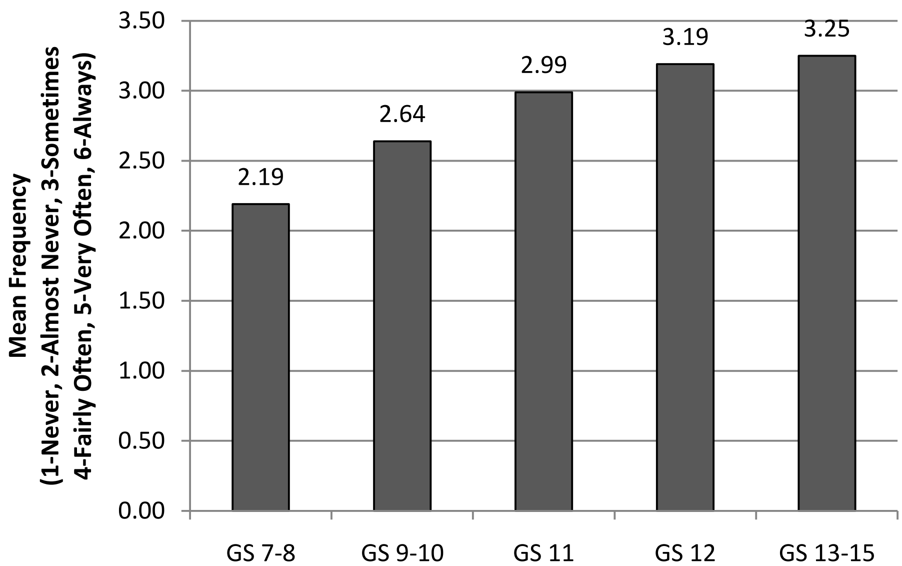
Uncertainty reduction theory, from the interpersonal communication discipline, suggests that individuals who have experience with each other are more likely to understand and trust each other, because they have less uncertainty, than those who don't have experience with each other (Berger and Calabrese 1975; Miller and Steinberg 1975; Albrecht and Ropp 1984). Thus, positive interpersonal relationships would be expected to facilitate the discussion and acceptance of new ideas (Albrecht and Ropp 1984, Zaltman and Moorman 1988).

"Well, a lot of it is through personal connections with people... You know, if I have a question, I'll just call up [names of three scientists], because I have personal relationships with those folks, which is a real advantage to working on [a forest near a research station]."

--USFS Fire Ecologist

The aforementioned groups (NPS employees, employees working centralized offices, line / staff officers, fire ecologists, long-term fire analysts, and those with graduate degrees) indicated they had relationships with scientists more frequently than other groups. In addition, higher graded employees (GS 12 and above) reported having more frequent relationships with scientists (Figure 8). Groups having more frequent relationships and discussions with scientists are likely to have less uncertainty when communicating with, and a lower chance of misunderstanding, scientists than other groups. This is especially likely for those working as fire ecologists and those with Doctorates, because these two groups had the greatest history of relationships with scientists. For example, see the sidebar quote on the previous page from an USFS fire ecologist when asked how the individual keeps up with new research.

Figure 8: Mean frequency of *relationship history with scientists*, by grade level (n=495).



Fire ecologists and fuels specialists were most frequently listed by fire / fuels specialists as the positions responsible for locating scientific tools and information relevant to fire / fuels management (Figure 9). Furthermore, fuels specialists spent a significantly greater percentage of their responsibilities on fire / fuels planning than all other positions except fire ecologists. Fuels specialists spent an average of 67% of their responsibilities on planning, compared to the Fire Management Officers, Assistant Fire Management Officers, and operations specialists surveyed, who spent approximately 50% of their time planning.

However, fire ecologists on average indicated they had relationships with scientists “fairly often,” whereas fuels specialists indicated they had relationships only “sometimes” (Figure 10). If relationships are important for building credibility and trust, and ultimately for facilitating effective communication about fire / fuels science, then upper level managers will want to create more opportunities for fuels specialists to interact, both formally and informally, with scientists. In addition, employees working in local offices indicated they had relationships with scientists only “sometimes,” whereas those working in centralized offices indicated they had relationships “fairly often”; therefore, fuels specialists working at local levels should be targeted as participants in such efforts.

Figure 9: Positions responsible for locating scientific information / tools, by agency.

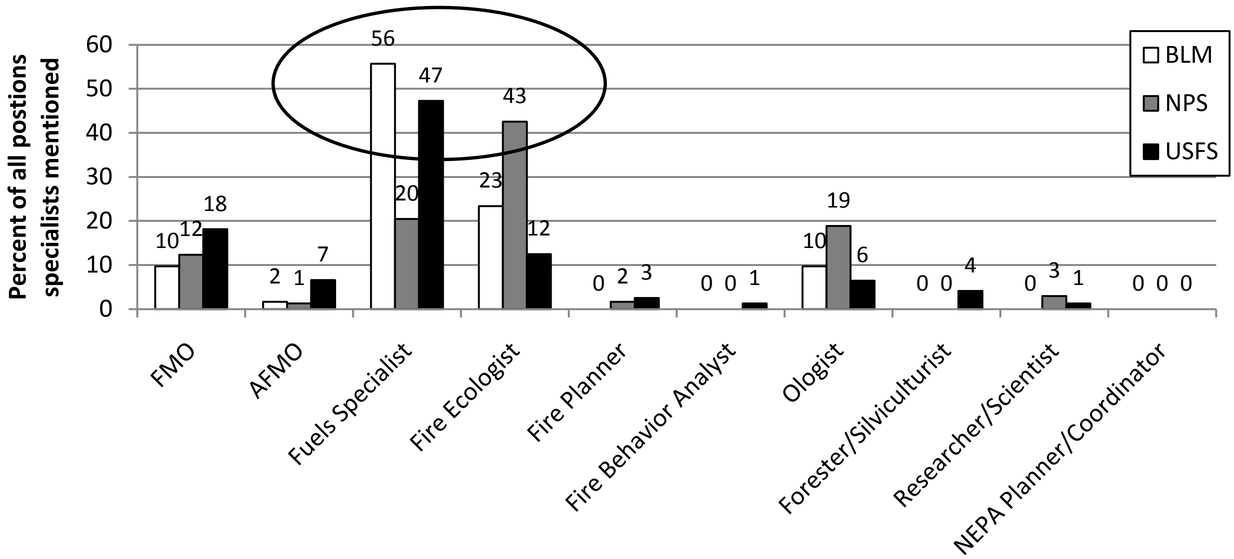
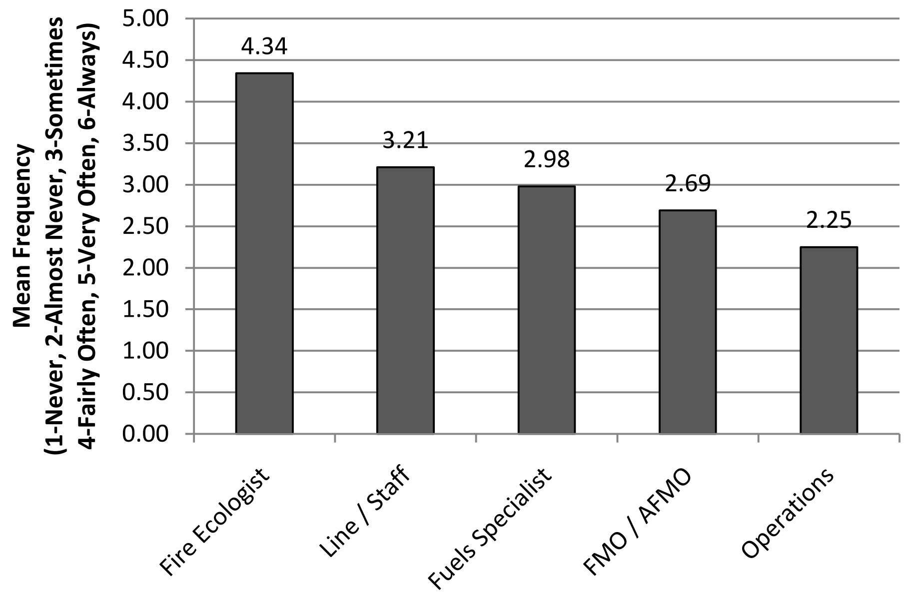


Figure 10: Mean frequency of *relationship history with scientists*, by position (n=495).



Workshops are a common way to foster interaction; these are more likely to facilitate relationship building if they are structured to include opportunities for informal interaction between managers and scientists. In addition, collaboration and relationship-building can be fostered through funding opportunities that require science-management collaboration, especially where monetary incentives are targeted for both scientists and managers. The adaptive management framework offers another option for facilitating ongoing relationships between scientists and managers (Graham and Kruger 2002), as does the current effort by the Joint Fire Science Program to develop regional science delivery consortia (JFSP 2009).

Innovation and Opinion Leaders

"One of the greatest pains to human nature is the pain of a new idea. It… makes you think that after all, your favorite notions may be wrong, your firmest beliefs ill-founded… Naturally, therefore, common men hate a new idea."

-- Walter Bagehot. 1873. Physics and Politics.
Quoted in Everett Rogers. 2003. Diffusion of Innovations.

The *Diffusion of Innovation* theory can guide proactive efforts to facilitate adoption and, eventually, diffusion of relevant and consequential innovations (Dearing 2005, Dearing 2009). In order to shorten the time lag to diffusion, science communicators can identify innovators, opinion leaders, and innovation champions, recognizing that each supports innovation in a different capacity. Innovators (the first adopters) are best for experimenting with and providing feedback on new innovations. In addition to providing feedback to scientists, innovators can be a source of information for opinion leaders and other early adopters who are weighing the advantages and disadvantages of adoption. Opinion leaders, who are essential for jump-starting diffusion, are a subset of early adopters who are perceived by their peers as objective, expert, and trustworthy; they usually function informally rather than authoritatively. The third category, innovation champions, can work within the formal hierarchy to complement the efforts of opinion leaders by proactively using advocacy, persuasion, promotion, and education internally to overcome implementation hurdles. Opinion leaders cannot serve as advocates per se, because that would reduce views of objectivity and respect by peers.

Survey respondents in this study scored higher on *individual innovativeness* than any other individual or organizational measure; this measure also had a relatively low standard deviation, indicating that innovativeness scores were not as varied as they were for most other measures. On average, survey respondents agreed slightly that they were willing to try new things. That said, higher pay grade levels, long-term fire analysts, and individuals with Master's degrees scored the highest for innovativeness, indicating these subgroups would be the most willing to try new ideas or tools. In contrast, individuals working at the GS 7-8 level, prescribed fire burn bosses, prescribed fire managers, and fire use managers who did not also hold other assignments, though still willing to try new things, were less inclined to be innovative than other groups.

Results were similar when respondents were split into adopter categories. Although early adopters occurred within all groups, there were more early adopters in the NPS, at the GS 12 and above grade levels, in line / staff officers and fire ecologist positions, in long-term fire analyst and fire behavior analyst assignments, and with Master's degrees. These are the most likely groups to look at when identifying early adopters in fire / fuels management, and thus, opinion leaders who can communicate the value of innovations to their peers. According to the *Diffusion of Innovation* theory, science communicators convey information about innovations to opinion leaders, who then generate interest among their peers. Following this approach, scientists and science communicators using traditional communication methods will be most effective by targeting early adopters. The rest of the fire / fuels management community likely adopts scientific innovations based on the influence of their peers (and innovation champions) rather than via direct science communication. As such, managers may want to recognize the role of informal communication and increase its likelihood for success. For instance, since fire ecologists and fuels specialists are already recognized by their peers as responsible for locating scientific tools and information relevant to fire / fuels management, finding and disseminating scientific information could be formally added to their duties, they could receive training to improve their ability to function in this role, and those who do exemplary jobs at science dissemination could be rewarded.

Beliefs and Attitudes

Beliefs about Research Usefulness

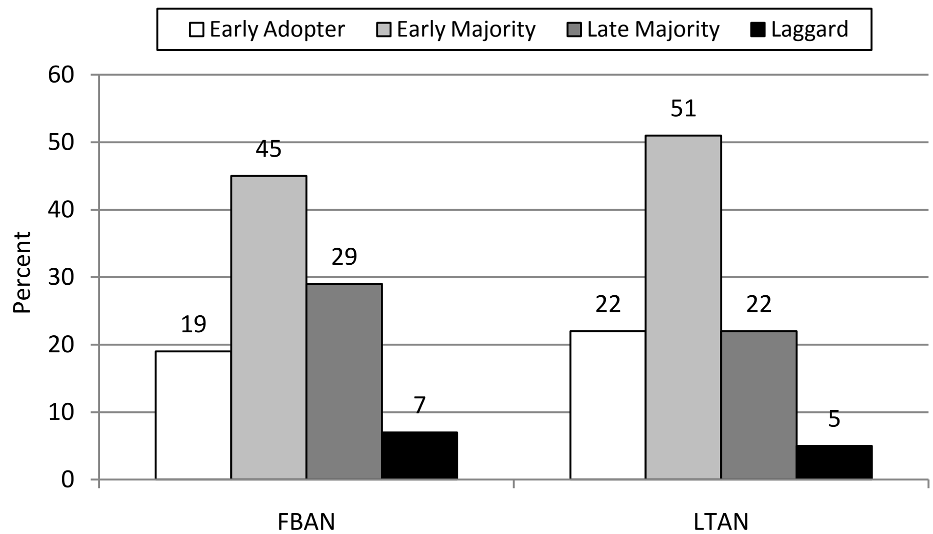
Decisions to use new information and tools are likely to be influenced by individual beliefs and attitudes. The *Technology Acceptance Model*, from the Management Information Systems field, has shown that beliefs about the usefulness of innovations, beliefs about the ease of using innovations, and attitudes toward innovations can influence use (Davis 1985). On average, respondents to this survey slightly agreed that research was useful for their jobs and they showed slightly positive attitudes toward using research. Differences were observed, however, by agency, administrative level, position, fire assignment and education level (see results reported in earlier section titled Fire Management Subgroups). Based on these results, it is critical that science communicators realize that some positions and some fire assignments rely more heavily on research than other positions and assignments. For example, see the following interview quote comparing Long-term Fire Analysts and Fire Behavior Analysts.

> *"There are quite a few FBANs who really don't use the models. I'm an LTAN… And we are more a culture of using the models, and FBANs aren't. FBANs are safety and operations. They're operation savvy."*
>
> *"The FBAN, the primary responsibility of the FBAN is firefighter safety… And they should be out on the fire line, really, and looking at fuels and looking at fuel moisture and figuring out, you know, is it crowning in this fuel type?"*
>
> *"And the LTAN is, I think, getting more, getting that feedback from an FBAN type person or a FOBS, a field observer position, and taking that feedback and trying to understand how they can use it to determine probabilities for really long events."*
>
> -- Long-term Fire Analyst (LTAN)

This LTAN quote suggests that FBANS don't use models as much because of their culture. Another LTAN, who was not part of the interview pool, explained that, not only are FBANs primarily focused on day-to-day safety, but many of them also have low confidence in models because they have been around long enough to remember the early models, which were based on poor data and had results that were hard to use. Supporting this assertion, the 63 FBANs surveyed averaged a 22-year tenure in fire /

fuels management (plus or minus a standard deviation of 9 years). Interestingly, FBANs responding to this survey scored nearly as high as LTANs on innovativeness, and they had similar proportions of early adopters (Figure 11).

Figure 11: Percent of Fire Behavior Analysts (FBAN) (n=31) and Long-term Fire Analysts (LTAN) (n=41) in each adopter category.



Yet FBANs had significantly lower scores for *beliefs about research usefulness* than LTANs. For example, see the following quotes.

"We put a lot of money, I mean, a lot of money goes to research, because nothing's cheap, for one. Make sure it matters. For example, 40 fuel models... Did someone on the ground say give me more fuel models? I need more complexity in my daily life? I'm guessing no."

"I don't use it. I'm not going to. I mean, I need four fuel models: brush, grass, timber, and slash. You know?"

-- Fire Behavior Analyst (FBAN)

"And I think they'll be especially useful in the fuels arena because we can show change in our models, whereas before, you know, you go in a stand of ponderosa pine . . . model 9 pretreatment, model 9 post-treatment. So you run the model you get the same answer even though you treated it.

So by saying, well, we changed the shrub component or we changed the grass component or we did this or that, then we can choose different fuel models and actually get different answers about fire behavior. That's helpful."

-- Long-term Fire Analyst (LTAN)

If upper-level managers in the fire community believe FBANs should be using more science to accomplish their objectives, they need to proactively work with this group to demonstrate the value of research. Thompson et al. (1991) suggested research usefulness could be a successful approach for personal computer (PC) technology:

> *"One partially controllable factor may be the beliefs about the level of correspondence between job tasks and the PC environment (i.e. job fit). Specifically, communication aimed at increasing the awareness of potential applications of PC technology for current job positions may influence the perception of job fit. "*

Based on empirical research, they suggested accomplishing this by using role models and / or champions:

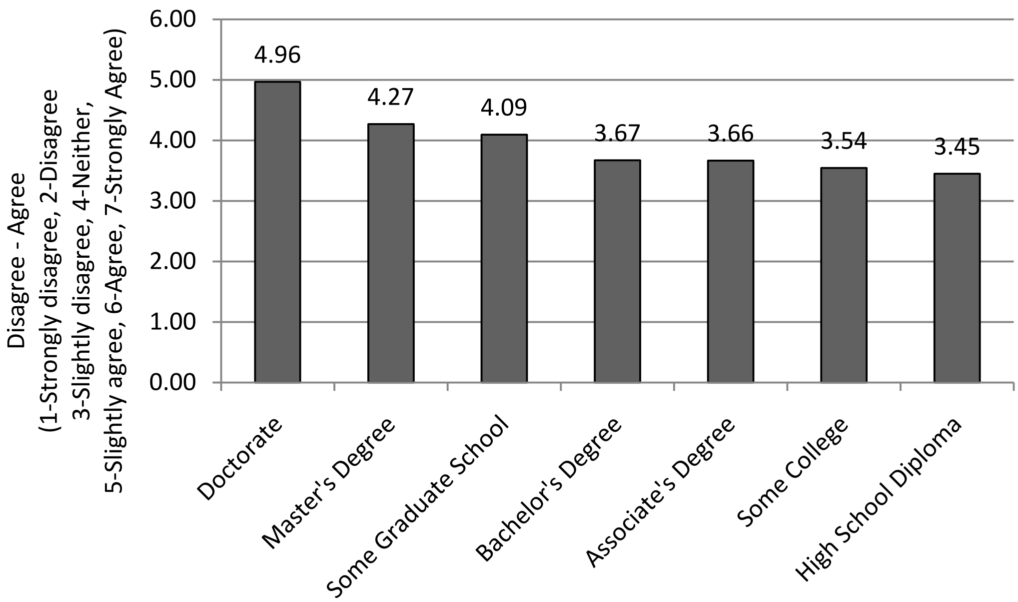
> *"Encouraging highly regarded, visible organizational members to use PCs may be an effective way of championing use throughout the organization."*

Until Fire Behavior Analyst *beliefs about research usefulness* are improved, science application will be more successful when results are communicated to the positions and assignments (for example, fire ecologists and long-term fire analysts) that are likely to be users of research. These groups should be targeted when disseminating research results relevant to their work.

Beliefs about Research Ease of Use

Regarding beliefs about *research ease of use*, respondents were, on average, slightly less than neutral. Thus, while respondents agreed that research was useful, they disagreed that it was easy to use. Notably, there was a large standard deviation for the ease of using research, indicating that perspectives on ease of use were varied. Beliefs about the ease of using research differed significantly only by education level (Figure 12). Respondents with any graduate education believed that research was easier to use than other groups. The *Diffusion of Innovation* theory contends that innovations that are more complex to implement will have a larger time lag before adoption; this has been supported by empirical studies (for example, see Agarwal 1997). Recognizing that survey respondents don't generally believe that research is easy to use, the impetus is on researchers with complex innovations to be sure that intended users receive training and support for implementation. In addition, for positions where research is used for a large portion of the job, providing opportunities for individuals to obtain graduate coursework will likely improve views about how easy research is to use.

Figure 12: Mean group scores for *beliefs about research ease of use*, by education level (n=495).



Attitudes about Using Research

An attitude can be defined as “a psychological tendency that is expressed by evaluating a particular entity with some degree of favor or disfavor” (Eagly and Chaiken 1993). Human behavior theory states that attitudes (i.e., feelings) are formed based on beliefs, and that attitudes influence behavior (Ajzen and Fishbein 1980). In this study, responses to questions measuring *attitudes about using research* were similar to responses measuring *beliefs about research usefulness*. Both measures had the same overall mean, and group comparisons showed similar patterns of significance by agency, administrative level, position, fire assignment, and education level. Though this study did not measure cause-effect, it seems likely *beliefs about research usefulness* are positively related to *attitudes about using research*. These results are not surprising, given that two studies from the Management Information Systems literature showed computer use to be more related to *beliefs about research usefulness* than *beliefs about research ease of use* (Davis et al. 1989, Thompson et al. 1991).

Beliefs about Scientists

Communication effectiveness is influenced by the perceived credibility of the speaker / writer. Credibility has two parts: trustworthiness (the communicator is truthful and has the audience’s best interests at heart) and expertness (the communicator knows what (s)he is talking about) (Hovland et al. 1953, Fazio and Gilbert 1986). Rogers (2003) labels these “competence credibility” (expertness) and “safety credibility” (trustworthiness). He describes a tradeoff between the two, noting that professional representatives of a Research and Development unit are likely to garner competence credibility, though it may be at the expense of safety credibility because developers (scientists) and potential adopters (managers) are often socially and culturally different. He concludes that an ideal communicator would have balance of these two types of credibility with their audience.

The survey measured *beliefs about scientist traits* that may influence communication effectiveness and / or working relationships with scientists. Beliefs about these traits (realistic, responsive, approachable, trustworthy, effective communicators, working for the benefit of managers, interested in relationships with managers) were slightly positive across all groups. This was the only scale that showed no differences among groups, indicating that beliefs about scientist traits were consistent regardless of agency, pay grade, administrative level, position, or education level.

Additional questions focused on scientist efficacy, including both trustworthiness and expertness. With regard to fire / fuels management, respondents slightly agreed that tax dollars spent on research were worthwhile and that scientists “know what they are doing.” However, scientists may want to work to improve beliefs about whether they are looking out for themselves or for managers, whether they are biased, and whether they can be trusted to study what is important. Responses to these questions, which reflected trustworthiness, were lower than the other efficacy questions, with the average response being neutral. Interestingly, when respondents were asked how they felt about scientists in general, they slightly agreed that scientists were trustworthy. However, when asked whether scientists could be “trusted to study what is important,” responses averaged as neutral, showing neither agreement nor disagreement.

Just as scientists differ in their approaches to science, interaction with managers, and collaboration (Graham and Kruger 2002), managers hold a variety of perspectives about scientists. The following quote is an example of a manager who has had good experiences with scientists.

> *“And I have found all the scientists that we have the pleasure of working with to be very, very responsive. Even though, you know, I think most of them, their hearts’ desire is to have the funding to be able to do long-term research and not have to answer any of these management kind of questions before the thing is baked and out of the oven. They are all very, very responsive in trying to help us. I mean, I think they clearly understand the management problems that we’re facing today and how important it is for us to have access to the best available science to answer those kinds of questions.”*
>
> -- Centralized Line Officer

In contrast, the following quotes suggest some managers have had negative experiences with scientists. They illustrate skepticism regarding the trustworthiness of scientists.

> *"When somebody asks, so you're very critical of this [research]. I said, well, you know, to me, you have to test a hypothesis, not prove it… So I tend to like researchers who honestly test their hypothesis. And we're all biased. We all have our own personal views and our own biases. And we wouldn't have gotten into a field if we didn't really like it, for the most part. So we are all biased. But you have to limit the amount of bias you put in a project."*
>
> -- Regional Fire / Fuels Specialist

> *"I think certain values that I mentioned earlier, the values that you bring into your field influence a lot of what direction your research is going to go and probably have some tendency to influence some conclusions you may draw..."*
>
> *"…And they [the scientists] would make, they wouldn't talk just about the science. They would talk about the management side of the, how they thought their science should be implemented on the ground and used and that sort of thing. So they blurred the line between I'm out there trying to collect the facts and present them to the manager for, from which then he will make decisions about how to use that science and application on the landscape. They blurred that line and went to the application of that science on the landscape as a "scientist." So that's, that's kind of what I was trying to counter with making sure that people that, that I had access to could provide that scientific expertise and, and maybe the conclusions that the public would draw from that is not everything that this particular Ph.D. said at the science panel is true, that there's another perspective out there."*
>
> -- Local Line Officer

It is important for scientists to realize that some potential users of fire / fuels science have had these types of experiences with scientists, and that, as a result, they may be skeptical. In fact, upon introducing a symposium on science, values, and policy, Rykiel (2001) observed that scientists who are "perceived to have a political agenda lose their credibility, and policymakers can therefore ignore any scientific information they provide." Miller and Steinberg (1975) emphasize that trust is more concerned with the motives, or reasons, behind a behavior than the behavior itself. When speaking to an unfamiliar audience, scientists may need to take extra care to show how their study design and conclusions are unbiased and objective. Although views differ about the role scientists should play in management (Lach et al 2003, Steel et al 2001), scientists will likely garner respect in management audiences by acknowledging their role in providing knowledge that managers can use to make value-laden decisions.

Rogers (2003) addresses communicator credibility in terms of homophily. Homophilous individuals have similar technical competence, socioeconomic status, beliefs, and subcultural language; whereas heterophilous individuals differ in these categories. Scientists and managers are often heterophilous (Warrington 2007, Wright 2007), which Rogers notes can lead to misunderstandings and, consequently, unheeded messages. While some degree of heterophily is necessary to infuse new ideas, communicators are likely to be more effective when they are homophilous with their audience. Communication by scientists can be supplemented with communication via boundary spanners, positions held by individuals who have some level of homophily with both scientists and managers. Referring to this trait as marginality, Ziller et al (1969) recommended that individuals with high marginality (that is, orientation toward two or more groups with different value systems) would be desirable as boundary spanners.

> *"A boundary spanner is a person who works at the interface of science and land management, acting as a bridge between the two cultures represented by research scientists and land managers."*
>
> *--USFS Boundary Spanner (Ritter 2006)*

Clark et al. (1998) advocated the use of boundary spanners to link natural resource science and management. Subsequently addressing the USFS, Mills et al. (2002) proposed the development of a cadre of boundary spanners (as professional managers working under Research and Development leadership) to help land managers use scientific information. The Rocky Mountain Research Station and the Bitterroot National Forest have experimented with this concept (Ritter 2006), and the USFS National Leadership Team explored the concept of developing such a cadre (USDAFS 2000). Several of the managers interviewed during this study expressed a desire for positions that are fully dedicated to helping managers obtain relevant scientific information. The boundary spanner concept likely warrants broader experimentation as a tool for facilitating effective science delivery. Interestingly, NPS interviewees described fire ecologists as filling such a role.

> *"I actually think the Fire Ecologists in particular, a lot of your job is to be the interface between the researcher and the more operational folks and the resource managers to get the best product you can from the researcher to make the researcher really relevant, even if the researcher doesn't have great skills in that area."*
>
> *--NPS Fire Ecologist*

Agency Culture: Science

On average, respondents from the fire / fuels management community agreed their agencies were supportive of science regarding public land management. However, levels of agreement differed by agency, grade level and fire assignment. NPS respondents scored higher for *agency support of science* than the other two agencies.

NPS respondents also scored higher than the other agencies on *beliefs about research usefulness*, *attitudes toward using research*, *experimenting* with new ideas, the *use / promotion of research*, and *relationship history with scientists*. The NPS also showed the greatest awareness of policy mandates to use science for public land management, both within the agency and among the interagency fire community.

> *"I think they [the NPS] put a lot more emphasis on science and research than the Forest Service does… I think it's just part of their culture... I think we're starting to get there more. But there's, you know, we're there because if we want to implement projects, we've got to know the best science and what kind of impact they're having on the ground. I think in the Park Service, you know, their emphasis on research has been there longer, just because they wanted to know. They just wanted to know the natural, how the natural ecosystem operates and how it functions. And I think theirs is more from just a pure scientific perspective."*
>
> *--USFS Interviewee*

Mission

Interview respondents across agencies described the NPS as having more of a science-oriented culture. They often attributed it to different agency missions. Similarly, the 2003 Interagency Strategy for Implementation of Federal Wildland Fire Management Policy noted that different missions influence fire management practices (USDA and USDI 2003). The following quotes reflect perceptions by agency fire / fuels managers.

> *"I think the Park Service, it isn't research, but the Park Service was the one, you know, that got the monitoring program going . . . and none of the other agencies are doing that. I don't know that they're grounded in the resources as much as the Park Service is, I mean, and that's what's driven that. So, yeah, I think in a broad sense the Park Service is a leader there [in the use of science], and that's probably more by mission of our agency."*
>
> *"We're more resource based than, you know, you look at what's the number one mission of the Forest Service which that's changed a lot more now but is timber and recreation. For Fish and Wildlife it's raising ducks. For BIA it's timber and providing money for the tribe, and our, I think we're more resource based."*
>
> *--NPS Interviewee*

> *"Well, I think the understanding; the value of fire and fire-dependent ecosystems, the National Park Service's mission is clear and provides better direction to the employees of what that is… The mission of the Forest Service and the BLM is much wider. And we haven't been able to clearly articulate the value of fire in fire-dependent ecosystems as the Park Service has."*
>
> *-- Another USFS Interviewee*

History

The three agencies compared also have very different histories related to science. From 1972-1993, the NPS had place-based scientists working in parks (Sellars 1997), which have since been replaced by a system through which most research is to be provided by a sister agency (USGS) and supplemented by institutions such as university-based Cooperative Ecosystem Studies Units and NPS place-based Research Learning Centers that facilitate research in and for specific Parks. This contrasts with the USFS, which also has a history of research scientists working within the agency; however these scientists have long worked in centralized offices managed by a separate research and development branch of the agency. In contrast to the NPS and the USFS, the BLM has had almost no history of scientists working within the agency. The few scientists who did work in the agency were moved to the National Biological Survey, and eventually the USGS, at the same time scientists were moved from the NPS to the National Biological Survey.

Role of Scientists

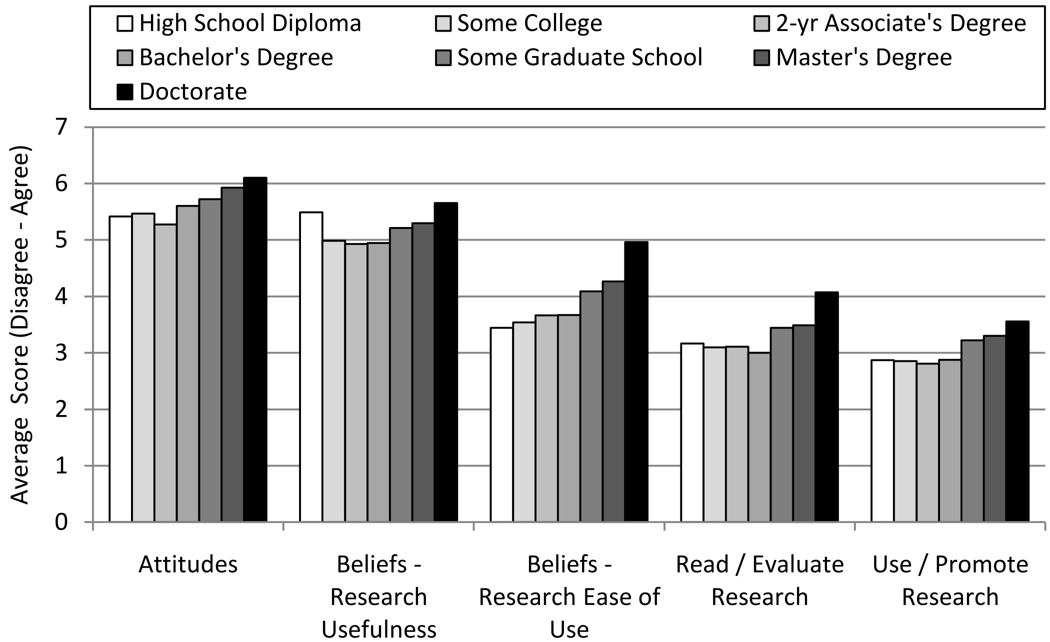
This study suggests that, at least for fire / fuels management, the NPS has a stronger science culture than either of the other agencies. In fact, this culture may reflect different roles that scientists have played in the different agencies. Lach et al (2003) described five distinct preferences among scientists, managers, and the public regarding the role of scientists in natural resource management. They defined roles ranging from reporting results (lowest involvement) to making decisions (highest involvement). It is possible that, while USFS scientists have historically performed the first two roles (reporting and interpreting results), place-based NPS scientists, where they have participated as resource management team members, have sometimes functioned in the third role (integrating scientific results directly into resource management decisions). Certainly, some USFS scientists have also participated in team efforts to integrate scientific results into management and policy; however, the implications for agency culture may be different when scientists join temporary, issue-driven teams than when place-based scientists work on ongoing teams that address a variety of management issues. In the latter situation, scientists and managers develop relationships that facilitate communication. Additionally, agency managers in such a scenario have more opportunities to interact with scientists and develop positive beliefs and attitudes toward using research.

Sociodemographics

Education

Study results show a link between graduate level education and perspectives on the following research-related measures: *attitudes toward research*, *beliefs about research usefulness*, *beliefs about research ease of use*, *searching for / reading / evaluating research*, and *using / promoting research* (Figure 13). Interestingly, those with Bachelor's degrees scored significantly lower than those with any graduate education, and they did not score higher than those without college degrees. However, the analysis did not differentiate between those with Bachelor's degrees majoring in the natural resources versus other disciplines.

Figure 13: Agreement/disagreement, on average, for measures that differed significantly by education level. Higher numbers indicate respondents agreed more with statements than lower numbers, ranging from (1)strongly disagree to (7)strongly agree (n=495).



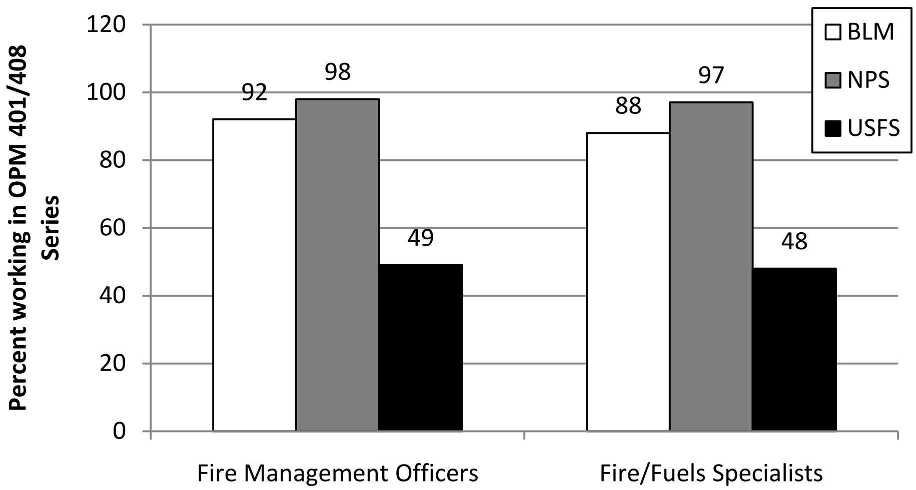
The NPS had a significantly higher mean education level than the USFS (with only 12% respondents having less than a Bachelor's degree, compared to 28% in the USFS). The BLM was closer to the NPS with only 17% having less than a Bachelor's degree (Table 1). In addition, within the GS 9-11 pay categories, which are primarily responsible for conducting or overseeing analyses and making recommendations to decision makers, NPS respondents had a higher mean education level than either of the other agencies (Figure 6). In contrast, the BLM's similar overall education level was derived from relatively high education of the GS 12-15 pay categories.

IFPM Qualification Standards

Interagency Fire Program Management (IFPM) standards were developed to improve firefighter safety and increase professionalism in fire management programs (FFALC 2004). According to an USFS white paper on IFPM (USDAFS 2005), "It is broadly believed that pursuit of natural resource related courses will enhance the abilities of our employees to analyze critical data and make and communicate better decisions." Scientific literature also supports the notion that professionalism (i.e., the percentage of professionals in an organization) is related to organizational innovation (Wilson 1966, Thompson 1965, Aiken and Hage 1971, Pierce and Delbecq 1977, Damanpour 1991). Because this study showed a relationship between education level and receptivity to science, and the scientific literature suggests professionalism is correlated with innovation, the IFPM effort to increase professionalism in fire management is relevant to understanding innovation and the use of research for fire / fuels management.

In addition to having the highest mean education level, the NPS had the greatest percentage of fire / fuels specialists working in the professional OPM series (401, 408, or 460), as required by the original IFPM qualification standards for key fire management positions at the GS-9 and above pay levels (Figure 14). In order to qualify for the 401, 408, and 460 series, individuals must have a minimum number of college credits in natural resources or related fields.

Figure 14: Percent of GS-9 and above Fire Management Officers (n=113) and Fire / Fuels Specialists (n=337) working in professional OPM series (401, 408, or 460), by agency. The remaining positions were in technician (455, 462) or fire protection (0081) series.



NPS

The IFPM 401requirements for professional positions may have been easier for the NPS to attain because most of their fire / fuels specialists working at the GS 9 and above, including at the park level fire management officers, were already working in this job series prior to the IFPM standards. This stems from previous efforts to professionalize the NPS workforce For example, see the following quote.

"I think we have a greater number of employees that have degrees so they meet the requirements for 401. And now when we have this IFPM program we're in a better position to have people achieve that by the 2009 deadline. And I think there's some that are already in the program so, thus, we've been able to work under professional people. So the FMOs have degrees, so they understand not only the fire side of protection, but they also understand the fire science and ecology side. And that, I think, is really the strength of the National Park Service program."

--NPS Interviewee

BLM

Similarly, the BLM has a high percentage of fire / fuels specialists working in the 401 series, likely because the agency established qualification standards for key fire management positions in the GS-0401 series, prior to adoption of IFPM standards, in April 1996 (USDA and USDI 2004). The BLM also made a concentrated effort to obtain 401 educational requirements after the IFPM standards were issued, for example, through the program at University of Nevada, Las Vegas.

USFS

The USFS, with the greatest number of fire / fuels specialists had the greatest number of fire / fuels specialists working in the technician series when IFPM standards were issued. Additionally, the USFS has many sub-unit (i.e., District or Zone) and subordinate positions that are considered uncharacteristic of the DOI agencies; these positions will continue as technician positions working in association with key positions at the forest, regional, and national levels which meet the IFPM 401 standards. At the time of this survey, the following positions were required to move toward the 401 series: forest fire management officers and assistant fire management officers, high complexity forest prevention and mitigation specialists, sub-unit fuels fire management officers, and sub-unit fire planners. In contrast, sub-unit fire management officers, moderate and high complexity wildland fire operations specialists, and moderate complexity forest fire prevention and mitigation specialists could be classified in either the 401 or 462 series. All other fire positions were classified as technical (462 series). This was in contrast to IFPM standards for the DOI agencies, which required fire program managers of all complexities, as well as high complexity operations, prescribed fire, and fuels specialists, to move toward 401 qualifications.

Currently, as interim guidance while the USFS evaluates the potential of establishing new job series (rather than 401 or 462) for wildland fire management work, USFS fire / fuels positions are required to meet the 401 fire management specialist qualifications only for forest fire management officers at the GS 13 and higher levels, the national fire program manager, and the geographic area fire program manager (USDAFS 2009). Of the 10 USFS fire / fuels specialists working at the GS 13 and above levels who completed the survey, all of them worked in the 401 series. This included 4 forest fire management officers, 5 national / regional fuels specialists, 1 forest operations specialist, and 1 regional fire ecologist.

Implication

Cultural change supporting increased education and use of science within the fire management community is a long-term undertaking. There have been challenges in implementing the education requirement of IFPM (Kobziar et al 2009). For now, current science communication strategies must consider that the BLM and, to a lesser extent, USFS audiences may have less education and less experience with scientists than NPS audiences. This is especially true for those working at lower grade levels.

Policy Mandates to Use Science

Fire / fuels managers are mandated by policy to use science, both as an interagency fire community and within each respective agency. Overarching the fire discipline, each agency is mandated to use science for National Environmental Policy Act land and resource management planning. Fire Management Plans tier to the land and resource management plans. This section summarizes policy specific to the use of science by fire programs, beginning with interagency wildland fire policy.

Interagency

The 1995 Federal Wildland Fire Management Policy & Program Review Final Report was the first single comprehensive federal fire policy for the Departments of the Interior and Agriculture (USDI and USDA 1995, USDI 2001). This report addressed the use of science and new knowledge in several places and included the following Guiding Principle:

"Fire management plans and activities are based upon the best available science."

The 2001 Federal Wildland Fire Management Policy Review and Update, as well as the 2003 Interagency Strategy for the Implementation of Federal Wildland Fire Management Policy, reiterated this guiding principal and further stated that:

"Fire Management Plans and programs will be based on a foundation of sound science."

In addition to requiring that science be used for fire / fuels management, interagency fire policy requires that science addressing management issues be funded, developed, and transferred to managers in a timely manner. For example, the 2003 Interagency Strategy states the following,

"This policy is intended to increase the body of scientific knowledge and understanding about fire management programs. Further, development of management tools and the transfer to management for use are included."

NPS

NPS wildland fire policy is documented in the NPS Management Policies and Director's Order 18: Wildland Fire Management. Director's Order #18 includes the following mission goal for the NPS Wildland Fire Management Program:

"Science based Management: General and park-specific science and research guides the wildland fire program."

Guidance on NPS wildland fire policy implementation can be found in Reference Manual 18 (RM 18) Wildland Fire Management. The current version of RM 18 (released January 1, 2008), in the chapter on fire management plans, states that fire management plans should be updated annually to incorporate the "best available science" and that five-year comprehensive fire management plan reviews should consider new science. NPS fire policy and implementation documents are more specific in their mandate to use science than the fire policies of the other two agencies studied. RM 18 also states the following,

"Research considerations are important to NPS fire management implementation… Existing research applicable to a unit's fire management program should be examined to aid in determining desired ecological conditions, developing appropriate management goals and objectives, and writing appropriate treatment plans."

Each NPS fire management plan must include a brief bibliography or summary of existing research applicable and important to the unit's wildland fire management program and desired conditions, a summary of ongoing fire research directly related to the NPS unit, and a summary of fire research needed to implement or refine the wildland fire management program and/or desired ecological conditions.

The fire ecology and monitoring chapter states,

'The park will support land management decisions and practices with science-based expertise."

In addition, RM 18 devotes an entire chapter to fire research, stating that the "primary objective of fire research in the National Park Service is to ensure that fire management activities are informed and supported by the best available scientific information." This chapter includes lists of, and links to, fire research funding sources, research support and assistance available to the NPS, and reference and research services.

USFS

USFS wildland fire policy is documented in the Forest Service Manual 5100 Fire Management (USDAFS 2005). Science is addressed in Sections 5101 (Authority), 5103.1 (Policies), 5104 (Responsibility), and 5107 (Principles).

In addition to reiterating the interagency guiding principle related to science, Section 5103.1 Policies reiterates that,

"Fire management plans and programs will be based on a foundation of sound science. Research will support on-going efforts to increase our scientific knowledge of biological, physical, and sociological factors. Information needed to support fire management will be developed through an integrated interagency fire science program. Scientific results must be made available to managers in a

timely manner and must be used in the development of land management plans, fire management plans, and implementation plans."

Section 5104 Responsibility also states that Research Station Directors are responsible for supporting research to improve fire management. These responsibilities address fire science delivery and application, including the following direction.

“Ensure that scientific results from fire research are available to fire managers in a timely manner and in the lay person's language... Provide strategies on how to implement scientific results in a practical manner in the field.”

Line / staff may be more familiar with FSM 1920 Land Management Planning than fire chapters of the Forest Service Manual. In the past decade, National Forest planning rules have changed several times. However, the 2005 rule was in effect during the time of survey distribution (USDAFS 2006). The 2000 rule was the first to introduce the language of “best available science,” and this language was still reflected in FSM 1921.85 Consideration and Application of Science as follows,

“*While the aim of research activities is to add to the body of scientific knowledge, planning draws from and applies this existing body of scientific knowledge. To assure the planning process properly accomplishes this, the Responsible Official shall conduct timely and substantive reviews of the best available science applied during the planning process.*

At the time the survey was distributed, FSM 1920 also included sections on the role of science and best available science.

BLM

With a process similar to that of the USFS, the BLM documents policy and policy implementation in manuals and handbooks. At the time this survey was distributed, the Fire Management section of the manual (Section 9210) hadn’t been updated to include recent interagency fire policy. Rather, BLM employees were directed through instruction memoranda to use interagency fire policy. More recently, Section 9211 of the manual, on Fire Planning, has been updated and issued through interim manual guidance. This section states the following,

“The BLM adopts current Federal Wildland Fire Management Policy. BLM fire planning documents must comply with these guiding principles and policy statements as stated in the 2001 Review and Update of the 1995 Federal Fire Policy,”

and reiterates the guiding principles and policy statements.

Group Comparisons

When asked whether they agreed that their agency was mandated by policy to use science, and when asked whether they agreed the interagency fire community was mandated by policy to use science, respondents in the NPS showed the greatest awareness of policy mandates to use science (Figure 15). In contrast, BLM respondents showed the lowest awareness of policy mandates to use science. These results concur with the discussion of agency differences in the previous section.

Higher grade levels showed a greater awareness of agency policy mandates than lower grade levels; however, there were no significant differences among grade levels for awareness of interagency fire community mandates to use science. Line / staff officers had significantly greater awareness of agency policy mandates than staff specialists (Figure 16). Overall, line / staff officers, and GS 13-15 employees in general, bordered on "agreeing" that their agencies were mandated by policy to use science, whereas other groups only "slightly" agreed. Although average scores showed slight agreement that respondents were mandated by policy to use science, 38% of fire / fuels specialists and 23% of line / staff officers, either disagreed or were neutral in their responses to the question about agency policy science mandates.

Figure 15. Agreement / Disagreement that *this agency is mandated by policy to use science*, by agency, for the NPS (n=126), BLM (n=86), and USFS (n=350).

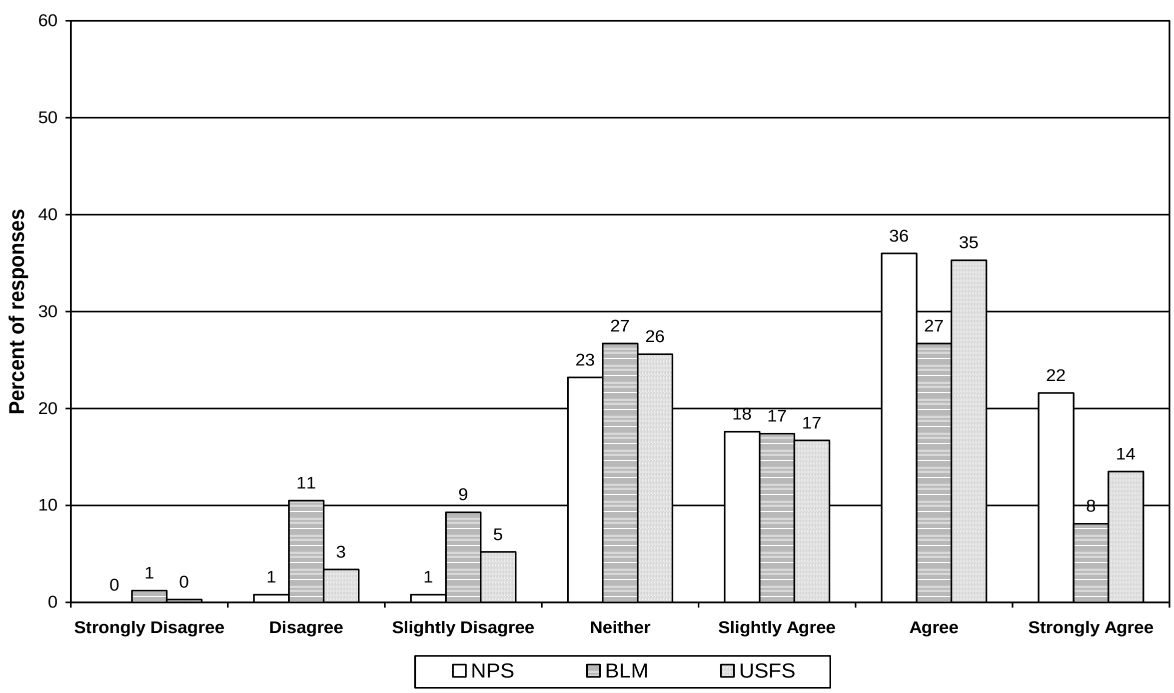
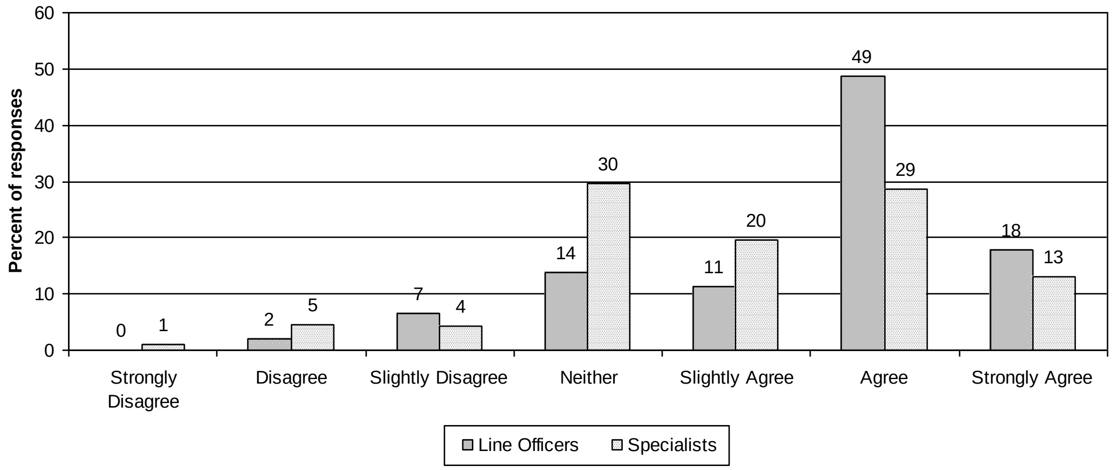


Figure 16. Agreement / Disagreement that this *agency is mandated by policy to use science,* by line / staff officer (n=152) vs. fire / fuels specialist (n=410).



Optimistically, it is possible this question was misinterpreted. However, results of the agency and grade level comparisons were consistent with other findings in this report regarding views toward science. If policymakers want to ensure that those responsible for fire / fuels management implement science-related policy, increasing awareness of policy mandates would be a straightforward place to start. The uncertainty about policy mandates to use science was greater for the interagency fire community (one-half BLM and USFS respondents and one-third of NPS respondents) than it was for individual agencies. Thus, increasing awareness of interagency fire policy mandates to incorporate science is an even greater need than agency-specific policy, which tiers to interagency fire policy in their manuals.

Organizational Learning

"In the absence of learning, companies—and individuals—
simply repeat old practices."

-- David Garvin. 1993. Harvard Business Review.

Garvin et al (2008) assert that the characteristics summarized in this section are important building blocks of learning organizations. The Garvin et al (2008) survey used for this analysis was not designed to critique organizations, but rather, to identify specific strengths and weaknesses and to promote dialogue about how to improve the learning environment. The assessment enables managers to focus on areas where improvement is likely to have the greatest impact on the organization.

Different Perceptions at Different Levels of the Hierarchy

A recent qualitative assessment of USFS safety culture (Dialogos 2007) identified several cultural patterns related to learning that were consistent with this study's results. The Dialogos memo notes,

> *"There is also a distinct hierarchy dynamic at play: Subordinates attribute they are not respected and therefore do not make use of possibilities to speak up (e.g., using an open-door policy, or at "participatory" meetings). Leadership then attributes that everything is fine—significantly underestimating the impact of hierarchy. The result is subordinates feeling disconnected and disempowered and leaders being overconfident and unwittingly stuck in ignorance."*

Dialogos was referring to safety and perceived risks, whereas this study addressed research use. Both assessments revealed that subordinates experience organization cultural characteristics differently than supervisors. This is consistent with classic descriptions of bureaucratic organizations (Weber 1947, Thompson 1965, Zaltman 1973). In this study, the highest grade levels (GS 13-15) reported significantly higher scores for *psychological safety*, *appreciation of differences*, *openness to new ideas*, and *analysis*. For *psychological safety* and *openness to new ideas*, the GS 13-15 grade levels rated statements as "moderately" accurate, while other grade levels rated them only as "slightly" accurate.

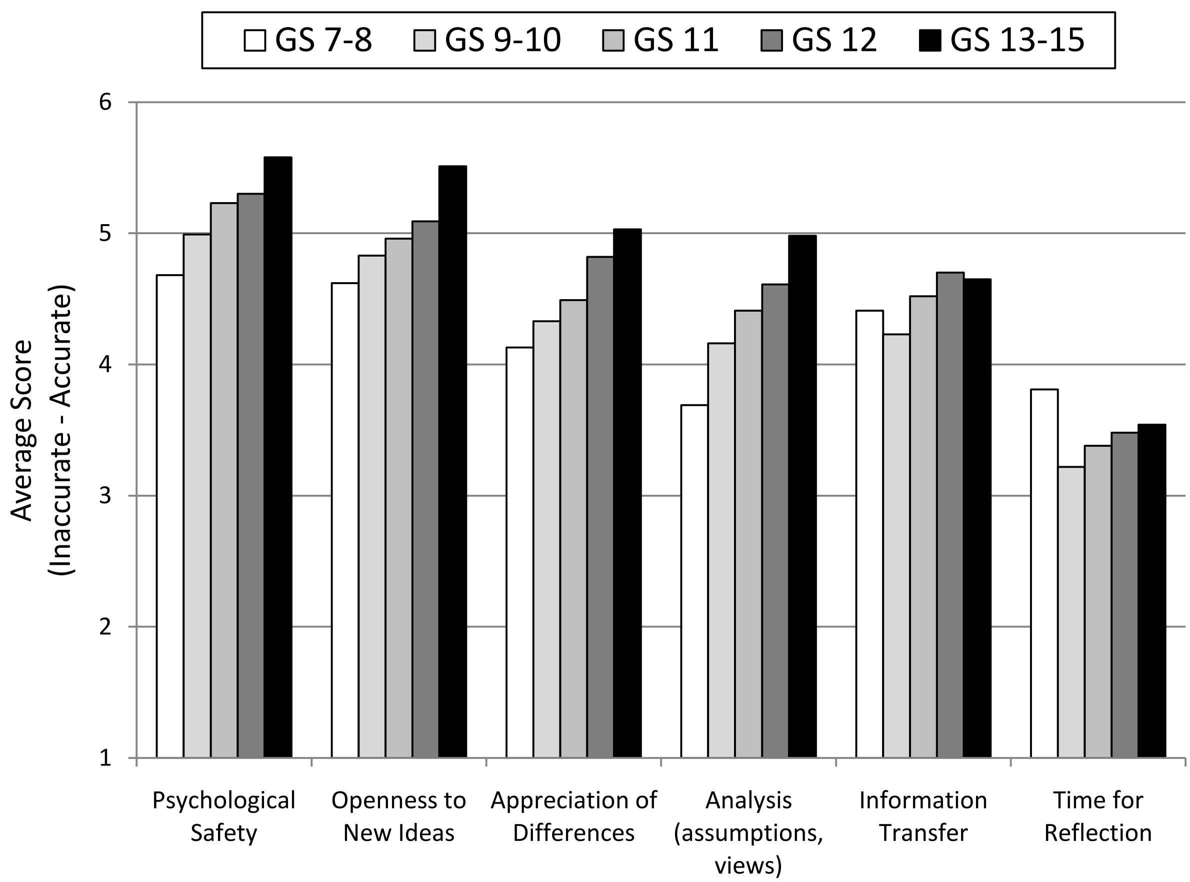
New ideas are essential for learning (Garvin 1993). Garvin et al (2008) note employees must feel psychologically safe in order to learn; they cannot learn if they "fear being belittled or marginalized when they disagree with peers or authority figures, ask naïve questions, own up to mistakes, or present a minority viewpoint." *Openness to new ideas (*i.e., valuing new ideas, openness to untried approaches, and interest in better ways of doing things) is important for organizational learning. While higher graded employees, on average, perceived *psychological safety* and *openness to new ideas* to be stronger, lower graded employees also perceived these characteristics to be present.

Of greater concern are scores for the *appreciation of differences* and *analysis* measures, for which the higher grade levels rated statements as "slightly" accurate but lower grade levels rated them as neutral (neither accurate nor inaccurate) (Figure 17). In general, work units that score high for *appreciation of differences* recognize differences of opinion and alternative worldviews, thus creating energy and preventing lethargy and drift. High scores for *analysis* mean work units engage in productive conflict and debate, seek dissenting views, revisit established perspectives during discussions, and discuss underlying assumptions (Garvin et al 2008). While surveyed employees on average indicated they felt psychologically safe to introduce minority ideas, they didn't necessarily feel these ideas were welcome or likely to be debated. Senge (1990) and Senge et al. (1994) describe the role of underlying assumptions in the failure of good ideas at being incorporated into management.

This study's results were similar to those obtained when the Wildland Fire Lessons Learned Center administered the learning organization survey to the wildland fire community during summer 2005 (Gino 2005). Summarizing 196 responses, Gino concluded that *appreciation of differences* was rated as lower than *psychological safety* (called climate) and *openness to new ideas*, thus providing a focused area for improvement. She suggested that investment in improving *analysis* would be worthwhile.

In general, higher graded employees (especially those at the GS 13-15 level) had more positive perceptions of the organization relevant to support for science and trying new ideas than lower graded employees. Higher pay grade levels had significantly higher scores than lower grade levels for perceptions of the learning organization characteristics *psychological safety*, *appreciation of differences*, *openness to new ideas*, *analysis*, and *information transfer,* as well as *individual innovativeness*. Higher pay grade categories (GS-11 and above) also had significantly higher perceptions of *agency support* for using science than the lower pay levels (GS 7-10). Whereas innovativeness measures an individual trait, the rest of the measures that higher graded employees scored high on reflect organizational traits. Additionally, higher graded employees were generally neutral as to whether the following were barriers to research use, whereas lower graded employees slightly agreed they were barriers: limited discretion and flexibility allowed in decision making, scientific recommendations that conflict with agency priorities, conflicting agency policy and directives, anticipation of appeals and/or litigation, lack of knowledge about who to contact about research, lack of reward for using research, and lack of appreciation for being innovative.

Figure 17: Perceived accuracy / inaccuracy, on average, for learning organization characteristics that differed significantly by grade level. Higher numbers indicate respondents rated statements as more accurate (i.e., 4=neither accurate nor inaccurate, 5=slightly accurate, 6=moderately accurate) (n=495).



If managers and supervisors want to encourage innovation in their programs, it is imperative they realize lower graded positions have different perspectives than they do. For those familiar with the literature on bureaucracies, these results are not surprising. Bureaucracies are fundamentally hierarchical with the expectation that subordinates obey directives from above (Weber 1947, Zaltman 1973); thus, bureaucracies are not inherently conducive to innovation (Thompson 1965, Damanpour 1991). For example, forty years ago, Thompson (1965) noted, "It has become commonplace among behavioral scientists that the bureaucratic form of organization is characterized by high productive efficiency but low innovative efficiency."

Addressing Max Weber's (1947) classic view of bureaucracies, Thompson (1965) explained hierarchical structures that ignore conflict depress creativity, whereas structures that allow conflict encourage innovation. Zaltman (1973) also noted conflict between those striving for innovation and those resisting the innovation is typical of the innovation process. Furthermore, literature on organizations and innovations supports fostering an "organic" rather than a "mechanistic" organization (Burns and Stalker 1961, Zaltman 1973). "Organic" organizations, which function best when in environments experiencing change (including scientific discoveries or technical inventions), have the following characteristics (Burns and Stalker 1961):

- openly value cosmopolitan knowledge / expertise / skill in addition to local knowledge / expertise / skill
- recognize knowledge can be located anywhere in the network
- operate under a network structure of control / authority / communication (rather than hierarchical)
- promote lateral communication over vertical
- communicate advice and information rather than instruction and decisions
- value commitment to tasks at hand over loyalty and obedience.

In reality, organizations and work units exhibit these characteristics along a continuum between extremes, with different traits exhibited in different conditions. Work units that foster such "organic" management approaches are more likely to function as learning environments that support adopting new ideas and approaches.

In summary, leaders wishing to nurture a learning environment will need to recognize that subordinates have different perceptions of organizational culture. These leaders will want to promote an environment in which the validation of different opinions and productive debate are cultivated *at all pay grade levels*. Gino (2005) recommended that seminars or unstructured sessions examining the value that different backgrounds, skill sets, and ideas can contribute to organizations may improve the *appreciation of differences* within a work unit.

Information Transfer

Information transfer measured the extent to which respondents indicated their work units learned from and shared information within and outside the organization. The average score for *information transfer* was halfway between neutral and "slightly" accurate, with the only significant differences in perception evident among different grade levels. The score for GS 9-10 was significantly lower than GS 11, GS 12, or GS 13-15, suggesting that GS 9-10 employees perceive less communication than higher grade levels (Figure 17). This follows Monge et al's (1978) conclusion, based on their review of organizational communication structure, that "the single best predictor of a person's total communication amount appears to be his organizational status" where "high-ranking individuals communicate more while performing their jobs than do lower status persons." Different perceptions at different grade levels for *information transfer* are consistent with this study's findings for *psychological safety*, *openness to new ideas*, *appreciation of differences*, and *analysis*. Average scores for *information transfer* were also similar to those obtained by Gino's (2005) survey of the wildland fire community.

Garvin (1993) offers several suggestions to improve knowledge transfer within an organization. These include personnel rotation programs that enable individuals to learn through personal experience, transferring experts to different parts of the organization to distribute their knowledge more widely, and transferring experienced line officers to staff leadership positions where they can distill and diffuse their knowledge. These recommendations could be accomplished by increasing opportunities for detail assignments of either key positions responsible for using science (e.g., fuels specialists) or those likely to be knowledgeable about recent research (e.g., fire ecologists and early adopters from all categories).

Time for Reflection

Dialogos (2007) also identified a lack of time for reflection as an impediment to learning. For example, see the following excerpt from their April 2007 diagnostic memo:

> *"In a culture heavily focused on "can do," the necessary element of time for reflection in order to actually learn from all the "doing" gets disabled and frequently discarded in favor of simply continuing to keep "doing." This gets rationalized with being too busy to stop and learn."*

In this study, survey respondents across all grade levels scored lower on time for reflection than any other learning organization characteristic (Figure 17), with the USFS scoring significantly lower than both the NPS and BLM on time for reflection. Furthermore, when asked how strongly respondents agreed or disagreed with each of 16 potential barriers to using research, they agreed that "lack of time" was a barrier more than any of the

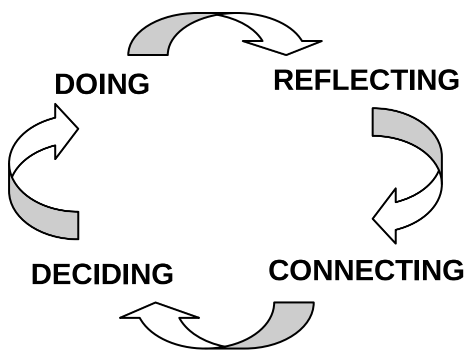
> *"I think one of the things that's happening in the agency is this, is burden shift. Probably one of the biggest things we face… There's a lot of things that we do in here now, that I do as an FMO that I never would have done… Admin. stuff, processing… And not that I'm above that. But, I mean, it's not just my travel I mean, I have to deal with Hotshot crews, the time that they generate. And these guys aren't like . . . you know, at a computer terminal somewhere. You know, I mean, it's . . . and 20 other firefighters..."*
>
> *--USFS Fire Management Officer*

others listed. For example, nearly 70% of respondents agreed that lack of time was a barrier, whereas only 45% agreed that lack of knowledge on how to find relevant research was a barrier. Interviewees also expressed concerns about time, citing an increased workload that included both the greater administrative burden and upward reporting.

Earlier recommendations included fostering an environment in which the validation of different opinions and productive debate are cultivated. Complementing this, the agencies will only be able to apply the best available science to fire / fuels management if they prioritize their employees spending time to learn about and experiment with applying scientific innovations. Garvin et al (2008) summarize the importance of time for reflection: "When people are too busy or overstressed by deadlines and scheduling pressures, however, their ability to think analytically and creatively is compromised. They become less able to diagnose problems and learn from their experiences." This statement is substantially founded in the innovation literature, which cites time as an important resource for cultivating innovation (Amabile et al 1996, Woodman et al. 1993).

For example, Senge et al (1994) describe a "wheel of learning," that cycles between doing (performing a task), reflecting (thinking and feeling), connecting (ideas and possibilities), and deciding (on a method of action) (Figure 18).

Figure 18: Wheel of learning, showing both action and reflection stages [adapted from Senge et al 1994].



In fact, individuals have different styles, with some more prone to "reflecting" and some more prone to "doing" (Kolb 1984). Kolb notes that the most powerful teams include representatives from each of the four styles. Ultimately, leaders are responsible for keeping the "wheel" moving so that it gives attention to all components, but doesn't get stuck on one stage (action or reflection) at the exclusion of others (Senge et al 1994).

Providing administrative support and increasing the efficiency of administrative reporting would allow for more time for reflection, especially if supervisors emphasized the need to periodically take time to reflect on established processes, underlying assumptions, and the potential application of new approaches to addressing management needs.

Experimentation

Learning organizations are skilled at both acquiring new knowledge *and* at changing behavior to reflect new knowledge and insights (Garvin 1993). Most of the work unit characteristics measured assessed culture and processes that support "acquiring, communicating, and assessing" new ideas whereas this study's measure of *experimentation* assessed how often work units experiment with "applying" new ideas.

Experimentation received the second lowest score among measured learning organization characteristics, scoring only above *time for reflection*. Overall, survey respondents scored neutrally on *experimentation*, citing associated statements as "neither accurate nor inaccurate." The exception was the NPS; NPS respondents rated the statements halfway between neutral and "slightly" accurate. This was consistent with other measures where the NPS scored higher than the other two agencies.

Based on a survey of 139 wildland fire and fuels managers in the western United States, Hohl (2007) found similar results regarding experimentation. When Hohl asked respondents to agree-disagree with the following two statements, "My agency encourages experimentation and risk taking" and "My agency documents its experiments, new knowledge, and learning over time," the average responses of fire managers were neutral (2.83 and 3.10, respectively along a 5-point response scale). Though responses to the first question may have been confounded by its inclusion of risk taking, results of both questions about experimentation were similar to this study's results. Both surveys suggest the wildland fire community is not proactive in experimenting with new approaches.

In addition, based on administration of the same learning organization survey to 125 senior executives from a variety of industries, Garvin et al (2008) provided benchmark scores for each of the leaning organization factors. They recommended that work units that take the survey initiate improvement efforts for measures that scored below their benchmark median, and especially for measures that fell in the bottom quartile. When comparing this study's results for line officers with Garvin et al's benchmarks for executives, line officer scores were in the bottom quartile of the executives' benchmarked scores for only two factors: *openness to new ideas* and *experimentation*. In Garvin et al's analysis, executives scored much higher on *openness to new ideas* than any other learning organization factor; this explains why the scores observed for *openness to new ideas*, though not particularly low, were in the bottom quartile of the benchmarks. However, the benchmarked executives' scores for *experimentation* were the fifth highest of nine factors. The fact that this study found *experimentation* to be in the bottom quartile for a factor where the benchmarked executives scored only moderately suggests that the federal fire / fuels community may want to focus on improvement in this area.

For those interested in learning through experimentation, Garvin (2000) devotes a chapter to describing the experimentation process. His descriptions of experimentation range from exploratory experimentation to rigorous hypothesis-testing. He argues that without experimentation, inferences and conclusions are based on existing knowledge—a process that works when there is already a large knowledge base. However, experimentation is especially important when outcomes of actions are uncertain (Gino 2005). While recognizing the practicality of working in an organizational setting, Garvin (2000) emphasizes the importance of clearly identifying the purpose of an experiment and carefully designing it to enable discrimination between alternative explanations, avoid interpretive errors, and either confirm or disconfirm prevailing views (Garvin 2000).

Adaptive management has been suggested as a systematic approach for experimenting with new science addressing natural resource management, especially in the face of uncertainty. The following authors provide recent overviews of adaptive management: Williams et al. (2009), Stankey et al. (2005), and Murray and Marmorek (2004). However, adaptive management has proved challenging to implement for a variety of reasons. The following resources describe the challenges to, and / or evaluations of, efforts to apply adaptive management to federal land management issues: Bormann et al. (2007), Stankey et al. (2006), Stankey et al. (2003), Lee (1999), and McLain and Lee (1996). Hohl's Master's thesis (Hohl 2007) offers a preliminary assessment of wildland fire managers' perspectives on the types of interactions between wildland fire managers and researchers that are deemed necessary for adaptive management.

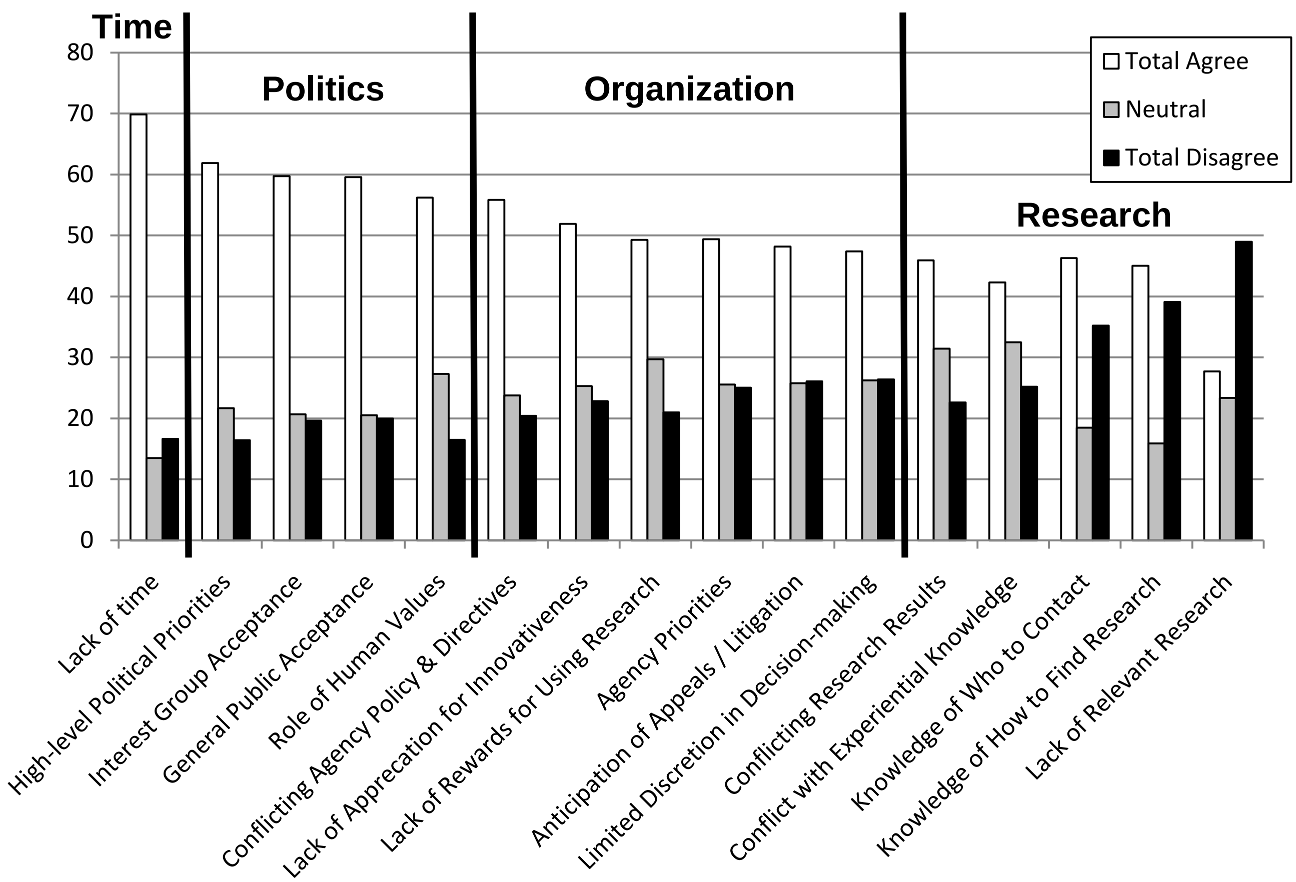
Supervisor Support of Innovation

In addition to literature that relates leadership behavior to the performance / productivity of employees, leadership can specifically influence how innovative individuals are in the workplace (Basadur 2004, de Jong and Den Hartog 2007, Garvin et al 2008, Zhou and Shalley 2003). Based on work by de Jong and Den Hartog (2007), this survey measured perceptions about the following supervisor characteristics that might influence innovation: innovative role-modeling, intellectual stimulation, stimulating communication for knowledge diffusion, providing vision/direction for innovation, consulting with employees, delegating sufficient autonomy, supporting innovative employees, providing feedback, recognition of innovative performances, resources for idea implementation, monitoring, and challenging task assignment. On a 5-point scale assessing frequency from never to always, respondents indicated that supervisors exhibited these traits "sometimes." USFS employees reported that their supervisors exhibited the traits significantly less frequently than did employees of the other two agencies (though the difference was small). This study's results indicate that there is room for improvement in leadership to support innovation. Earlier discussion of different perceptions among grade levels provided some suggestions for improvement (e.g., increased communication across grade levels). Additionally, leaders can focus on the traits listed here, which reflect the most recent scientific understanding on leadership behaviors thought to stimulate innovation.

Barriers to Research Use

While this survey primarily measured individual and organizational characteristics that are likely to influence the use of research, the survey began by asking opinions about a broader list of potential barriers to the use of science. This list drew from the range of organizational and external barriers identified during agency meetings early in the project (Figure 4). Respondents agreed more that lack of time to use research was a barrier than any other barrier (Figure 19). This was followed immediately by a group of external barriers related to the influence of high-level politics, public interest groups, the general public, and the role of human values in management decisions. Next was a group of institutional-related barriers: conflicting agency and policy directives, lack of appreciation for being innovative, and lack of rewards for using research. The final group of barriers was also external. Research-related barriers included: research results that conflict with other research results, research results that conflict with experiential knowledge, lack of knowledge about who to contact about research, and lack of knowledge about how to find relevant research. Notably, lack of relevant research was the only statement that respondents disagreed was a barrier more than they agreed with it (49% disagreed, 22% were neutral, and 28% agreed).

Figure 19: Agreement/Disagreement with 16 potential barriers to using research. Listed from highest mean score to lowest (highest agreement, on average, to least) (n=530).



This report makes recommendations to science communicators and upper level managers interested in improving science delivery and science application. In order to successfully integrate the best available science into fire / fuels management, science communication must incorporate an understanding of the audience, and message recipients must work in environments that are receptive to innovation. Yet, responses to the “barrier” questions remind readers that the use of science is also tempered by human values, by the public’s acceptance of scientific recommendations, and by politics. Politics as a barrier to the use of science has been described previously (Union of Concerned Scientists 2004, United States House of Representatives Committee on Government Reform 2003). If scientific recommendations are not compatible with contemporary views held by the public and their representatives, adoption and diffusion may either be unachievable or deferred until views change. As Rogers (2003) observed, “an innovation’s incompatibility with cultural values can block its adoption.” Nevertheless, recommendations in this report are intended to shorten the time to adoption for the many scientific innovations which are compatible with public values.

Implications / Recommendations

For Managers

1. Awareness of policy mandates to use science needs to be increased. Fourteen percent of line / staff officers responsible for fire / fuels management were uncertain whether *their agencies* were mandated by policy to use science, and 9% disagreed. Thirty-five percent of Line / Staff Officers were uncertain whether the *interagency fire community* was mandated by policy to use science, and 24% disagreed. Uncertainty about policy mandates was even greater for fire / fuels specialists.
2. Fire Ecologists and Fuels Specialists were the most commonly cited positions that locate scientific information and tools that support fire / fuels management. However, Fuels Specialists had lower scores than Fire Ecologists for *innovativeness*, *beliefs and attitudes about research*, *history of relationships with scientists*, and *use / promotion of research*. Based on their position responsibilities, fuels specialists would be an ideal group to target for opportunities to interact, formally and informally, with scientists. This is especially true for local and mid-level (GS 9-11) positions.
3. Programs that encourage Fuels Specialists to obtain graduate coursework and / or degrees would increase familiarity with the ease of using research. Increasing the proportion of fuels specialists who are familiar with research so they can communicate the usefulness and ease of use to their peers would likely increase overall adoption of relevant science products.
4. Since fire ecologists and fuels specialists are recognized by their peers as responsible for locating scientific tools and information relevant to fire / fuels management, it would be beneficial to formally add finding and disseminating scientific information to their duties, provide training to improve their ability to function in this role, and rewardthose who do exemplary jobs at science dissemination.

5. Fire Behavior Analysts would be another group to target for opportunities to interact more with scientists. This group scored high on *individual innovativeness* but relatively low on *beliefs and attitudes about research* and *use / promotion of research*.
6. Higher grade levels reported a greater sense of *appreciation of differences*, *analysis*, and *information transfer* than lower levels. Leaders wishing to promote learning in their work units will want to actively foster an environment that cultivates communication, validates different opinions, and encourages productive debate at low and middle pay grade levels (below GS 13).
7. *Time for reflection* and *experimentation* received the lowest scores of any learning organization attribute. Garvin et al (2008) summarize the importance of time for reflection: "When people are too busy or overstressed by deadlines and scheduling pressures, however, their ability to think analytically and creatively is compromised." In addition, experimentation, ranging from exploratory to hypothesis testing, is important when outcomes of actions are uncertain (Garvin 2000). *Time for reflection* and *experimentation* represent challenging yet critical opportunities for improvement at all grade levels.
8. In cooperation with scientists, designate boundary spanner positions who understand both management and research cultures and are dedicated to finding, communicating, and evaluating relevant scientific resources.
9. Supervisors wishing to nurture innovation in their employees will want to focus on innovative role-modeling, intellectual stimulation, communication to diffuse knowledge, providing vision / direction for innovation, consulting with employees, delegating sufficient autonomy, and supporting innovative employees. They will want to provide feedback, recognition of innovative performances, resources for idea implementation, monitoring, and challenging task assignment.

For Scientists

1. Even for relevant and consequential innovations, there is a time lag between the introduction of new ideas or products and their widespread use. Thus, it is unrealistic to expect that research application will be immediately observable.
2. Regarding effective communication, credibility has two parts: trustworthiness (the communicator is truthful and has the audience's best interests at heart) and expertness (the communicator knows what (s)he is talking about). *Beliefs about scientist traits* that influence communication effectiveness and / or working relationships with scientists were slightly positive across all groups. However, scientists may want to work to improve beliefs about whether they are looking out for themselves or for managers, whether their work is objective, and whether they can be trusted to study what is important to managers. They will be more credible if they demonstrate that they have the audience's best interests at heart.
3. In cooperation with managers, experiment with boundary spanner positions to supplement scientist communication by individuals who understand research but are more socially and culturally similar with managers.
4. Based on *beliefs and attitudes about research*, *relationship history with scientists*, and frequency of *research use / promotion*, the following subgroups are likely to be the most receptive to scientific messages: NPS employees, those working in

centralized offices (National, Regional, State), Line / Staff Officers, Fire Ecologists, Long-term Fire Analysts, and individuals with graduate degrees. Based on *individual innovativeness*, higher grade levels (GS 12 and above) and Fire Behavior Analysts are also early adopters. This is in contrast to, for example, operations specialists, fire management officers, assistant fire management officers, and fuels specialists.

5. The groups listed in #3 reflect the best groups to target when identifying early adopters, and thus, opinion leaders who can communicate the value of innovations to their peers. Once opinion leaders adopt innovations, they more effectively generate interest among their peers than external communicators.
6. Fuels Specialists (USFS, BLM) and Fire Ecologists (NPS) are responsible for sharing scientific information with other fire management positions, including Fire Management Officers who then communicate with line / staff officers. Thus, in addition to early adopters, science should be delivered to Fuels Specialists. It is also valuable to deliver fire / fuels science to natural resource specialists and Silviculturists, as Line / Staff Officers also query these positions about science.

Conclusion

Social scientists have spent the past 50 years trying to understand innovations (Barnett 1953), the diffusion of innovations (Menzel and Elihu 1955), organizational communication (Bavelas 1950), and innovation in organizations (Burns and Stalker 1961). They've worked to refine theories of human behavior (Ajzen and Fishbein 1970) and administrative decision-making (Simon 1947). Following the advent of computer technology, the Management Information Systems discipline began exploring models of technology adoption (Davis 1985). I undertook this study with the hopes that fifty years of addressing these issues could help us, as scientists and managers, understand and address the science application problem.

Examining the immense multi-disciplinary bodies of literature relevant to the topics of science delivery and science application is a formidable task (Bandura 1986). Rather than a comprehensive understanding of the topic, I hope this study will help scientists and managers interested in science application move from ad hoc approaches into strategic approaches that draw from decades of existing knowledge about individuals and organizations. Above all, I hope this study offers insights into how to begin improving the effectiveness of science application for fire / fuels management.

Summarizing criticisms of diffusion research, Rogers (2003) notes many diffusion studies blame individuals for being slow to adopt innovations. Although individuals have different propensities for adoption, he acknowledges diffusion success is often the result of system-level processes. I have predominantly taken the system-level approach to understanding research use in the fire / fuels management community for two reasons. First, pre-eminent theories of human behavior and a plethora of organizational management writings conclude that there is a social, or system-level, component to adoption decisions. Secondly, managers hoping to improve the scientific basis of fire / fuels management decisions and actions have the greatest ability to address system-level issues. Likewise, researchers hoping to improve science delivery will be more successful if they account for the social context within which they are delivering.

Based on the compatibility of this study's findings with existing literature, science communicators will want to focus on improving their own credibility as well as targeting groups with high percentages of early adopters and positions responsible for using / communicating research. Simultaneously, upper level managers will want to focus on improving awareness of policy mandates, increasing the capacity of fuels specialists and fire behavior analysts to apply science, and cultivating learning environments that foster time for reflection, experimentation, information transfer, validation of different opinions, and productive debate for all grade levels.

Caveats

While I attempted to collect surveys that were representative of the entire target population (professional fire / fuels specialists and decision makers responsible for fire / fuels planning and implementation in the USFS, NPS, and BLM), including those with a variety of perspectives on research use, the sample may have been biased.

Several components of the population were under sampled, including BLM employees, those from the Eastern, Midwestern, and Alaskan geographic regions, national level employees, and NPS line officers. In addition, education, prevention, mitigation, dispatch, and purely operational or production-oriented positions were excluded from the population because these positions are not generally focused on fire / fuels planning and implementation. Finally, sampled females reported higher grade levels, higher education levels, and more line officer positions than would be expected based on percentages of females in the sample. It is not clear whether this is representative of women holding positions in the fire / fuels community, or whether it was an unusual sample of the population.

The original survey distribution plan was designed to distribute the surveys at meetings with time on the agenda for survey completion. This design would have reduced response bias that favored completion by those who are more interested in research than others. However, it was not feasible to allot time on the agenda at many of the 45 regional / state meetings and training courses where the survey was distributed. Even for meetings where the survey was allotted time on the agenda, it was often administered either just before lunch or at the end of the day, and participants were informed that the survey was voluntary and they could leave as soon as they completed the survey. I tried to increase the likelihood of responses by having a champion for the survey at each meeting, and by announcing that a widely respected leader in the fire community (Tom Zimmerman, and for NPS audiences, Dick Bahr) supported completion of the survey. Still, the survey may not reflect a true cross-section of the target population. If the survey distribution was biased, it likely favored completion by those with an interest in research. If this was the case, this study's results are optimistic, reflecting stronger beliefs and attitudes toward research than actually exist in the population. Even with an optimistic sample, different perspectives were evident among groups, and among measured scales. Similarly, barriers to the use of research and a lack of awareness of policy mandates to use science were evident. While the absolute scores reported might differ with a different sample, these results raise issues worthy of attention.

Recommendations about communicating to early adopters are based on the Diffusion of Innovations theory, which purports that most members of a social system are more likely to adopt innovations based on communication with internal opinion leaders, who already garner respect, than external communicators. While I did not identify opinion leaders per se, I identified groups of early adopters, of which opinion leaders are thought to be members. This was based on the premise that targeting early adopters for science communication, would expose opinion leaders who would potentially adopt and communicate with their peers about innovations. However, it is possible that some opinion leaders may not function as effectively across group categories as within categories. For example, although a greater percentage of surveyed women were early adopters, some men might be more influenced by men who are early adopters. Similarly, higher grade levels may not be as effective at communicating messages about innovations to lower grade levels, and long-term fire analysts may not be as effective at spreading messages to prescribed fire burn bosses. The question of effectiveness across group categories requires further investigation.

Finally, the perspectives presented here reflect those from the fire / fuels management community, including staff specialists and line / staff officers. Perspectives obtained from other disciplines, such as biologists and silviculturists may be different.

Future Work Needed

The Diffusion of Innovations theory suggests the length of the time lag to diffusion is influenced by audience characteristics (individual and social), communication, and innovation characteristics. This study attempted to understand audience characteristics of the individuals and the organizational context of their work. This study found differences in perspective among agency, pay grade, current position, fire assignment, and education level. Some differences reflected individual experiences and perspectives, whereas others reflected organizational-level processes. As a next step, I plan to use these data to assess the relative strength of individual versus organizational influences to research use. In other words, were this study's measures of research use more driven by differences among individuals or organizational characteristics? Understanding the relative importance of individual vs. social influences to research use within the context of fire / fuels management will provide guidance on where to spend limited management resources aimed at improvement of science application.

This study provided insight into some of the communication paths and barriers related to fire / fuels science application. Additional findings will be evident in the interview data summary. Still, there is room for additional research on the communication of fire / fuels science, including formal and informal networks and attributes that influence success. Although this study tapped the literature on communication and organizations, there is a plethora of additional literature that could provide insights in this arena.

This study primarily assessed research use from a NEPA planning perspective and within the organizational structure of formal Office of Personnel Management positions. Although I took a cursory look at fire assignments, I did not delve into the influences to research use for the operational side of fire management. Influences to research communication and use related to the physical sciences and technology within the management of incidents warrants study on its own.

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Crosswalk of Deliverables

Deliverables (Research)	Submission Date
Refereed publication based on survey analysis, targeted for *Society and Natural Resources* or *Administrative Sciences Quarterly* (originally targeted for *Conservation Biology*, but changed journal to increase rigor of social science methodological review)	May 2010
Non-refereed publication on recommendations (originally guidelines) to improve fire science application, targeted for *Fire Management Today* or USFS Research Paper	May 2010
Refereed publication based on interview analysis, targeted for *Society and Natural Resources*	October 2010
Non-refereed annotated bibliography based on literature synthesis, targeted for USFS General Technical Report (this was originally the earliest deliverable, but this product was delayed to incorporate ongoing literature review based on survey development, analysis, and discussion)	October 2010
Wright, V. 2007. Communication barriers to applying federal research in support of land management in the United States. Pages 55-62 In: Miner, Cynthia; Jacobs, Ruth; Dykstra, Dennis; Bittner, Becky, eds. 2006. Proceedings: international conference on transfer of forest science knowledge and technology. Gen. Tech. Rep. PNW-GTR-726. Portland, OR: US Department of Agriculture, Forest Service, Pacific Northwest Research Station.	July 2005
Deliverables (Science Delivery) (Completed)	**Type**
Technical and social influences to the success of fire science delivery: Project details and resources. [Created October 2006] Available: http://www.leopold.wilderness.net/research/fprojects/F016.htm.	Web page
Wright, V. 2006. Overcoming barriers to the use of science in National Parks (Session summary). In: David Harmon, Bruce M. Kilgore, and Gay Vietzke, eds. People, places, and parks: Proceedings of the 2005 GWS Conference on parks, protected areas, and cultural sites. April 2005. Philadelphia, PA.	Non-refereed publication
Influences to the Use of Fire / Fuels Research: Perspectives of Potential Users. January 2010. Fire Sciences Lab Seminar Series. Missoula, MT.	Presentation
Influences to the Integration of Management and Science: Understanding Potential Science Users. December 2009. 4th International Fire Ecology & Management Congress. Savannah, GA.	Presentation
To what extent does the federal wildland fire community function as a learning organization? April 2009. 10th Wildland Fire Safety Summit. Phoenix, AZ.	Presentation

Influences to science application by wildland fire managers. October 2008. Applying Conservation Science to Action. Annual Research Symposium of the Montana Chapter of the Society for Conservation Biology. Missoula, MT.	Presentation
Integrating research into fire and fuels management. Poster. September 2008. The ’88 Fires: Yellowstone and Beyond. Jackson Hole, MT.	Poster
Influences to the use of fire and fuels research by federal agency managers. March 2008. Fire Sciences Lab Seminar Series. Missoula, MT.	Presentation
Personal and organizational influences to the use of fire and fuels research by federal agency managers. October 2007. Human Dimensions of Wildland Fire Conference. Fort Collins, CO.	Presentation
Integrating science into fire and fuels management. Poster. April 2007. George Wright Society Conference. St. Paul, MN.	Poster
Technical and social influences to the success of fire science delivery. Poster. September 2006. Joint Fire Science Program Board Meeting. Missoula, MT.	Poster
Barriers to effective science delivery and application. May 2005. Transfer of Forest Science & Technology Conference. Portland, OR.	Presentation
Creating an innovative organization: Overcoming barriers to the use of science. Day-capper. April 2005. The George Wright Society Conference. Philadelphia, PA.	Presentation
Social influences to the adoption of science. October 2004. Science & Technology Application Workshop. Athens, GA.	Presentation
Barriers to effective science delivery and application. May 2004. Joint Fire Science Program Fire Technology Transfer Meeting. Boise, ID.	Presentation
Research briefing (the Leopold Institute’s *Research in a Nutshell* series has been discontinued; however a research update was prepared and distributed at numerous venues; the latest version of the update is still available at http://www.leopold.wilderness.net/research/updates/U009.pdf.)	Research Briefing