DISSERTATION

INTEGRATIVE COMPLEXITY AND ATTITUDES TOWARD PRESCRIBED FIRE IN NORTHERN COLORADO AND SOUTHERN WYOMING

Submitted by

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In partial fulfillment of the requirements

For the Degree of Doctor of Philosophy

Colorado State University

Fort Collins, Colorado

Fall 2012

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ABSTRACT

INTEGRATIVE COMPLEXITY AND ATTITUDES TOWARD PRESCRIBED FIRE IN NORTHERN COLORADO AND SOUTHERN WYOMING

This research examined whether the relationship between basic beliefs about wildland fire management and attitudes toward prescribed fire are moderated by the level of integrative complexity. Households in counties adjacent to three study areas in northern Colorado and southern Wyoming were the target of this social science research. The primary goal was to further validate a recently-developed measurement tool for integrative complexity and apply it to a new research scenario. The second goal was to identify respondents' level of complexity when they think about the issue of prescribed fire. Results suggest that integrative complexity moderated the relationship between basic beliefs and attitudes toward prescribed fire. Consistent with theory and previous studies, results suggested no relationship between integrative complexity and attitude direction. However, as expected, results suggested a significant relationship between integrative complexity and attitude extremity. A conceptual model was developed which incorporates assessing public and stakeholder integrative complexity into the development of forest management plans. Findings should assist forest managers with the development of collaboration, education, and outreach strategies.

ACKNOWLEDGEMENTS

I firmly believe that no doctoral candidate receives his or her degree solely as the result of their own efforts. Many people are there along the route, listening and sharing, as well as providing support and guidance. It would be unforgiveable if I did not recognize those who assisted me in this endeavor. First of all, I would like to thank my friends and colleagues in the wildland fire community. Pete Barry, Sonya and Justin Whitesell, Jane Gordon, and Tony Simons have shared their knowledge of wildland fire management and encouraged me as I explored research opportunities. To this group I would add Glenn Casamassa, forest supervisor, Arapaho-Roosevelt National Forest and Pawnee National Grassland, who took the time to listen to my research idea in his headquarters parking lot one Sunday afternoon in 2009.

The next group I want to recognize is my academic family in the Department of Human Dimensions of Natural Resources. When Jeanne and I found ourselves dealing with the loss of our home, the department, as well as my fellow firefighters, was there. Their generosity truly humbled us and allowed us to meet many short-term needs. My fellow students have been a joy to be around. We're fortunate to have developed many good friendships. The staff and faculty have also been extremely helpful along the way. I'd especially like to thank my committee, Dr. Stuart Cottrell, Dr. Alan Bright, Dr. William Doe, and Dr. Joshua Goldstein. They have gone above and beyond the expectations of a doctoral committee. Their support as Jeanne and I met some unexpected twists and turns over the past two years means more than they will ever recognize.

Finally, I would like to thank my wife, Jeanne. Words can never express my love and appreciation for her patience, prodding, support, and inspiration while I earned my degree at Colorado State University. How can one guy be so lucky?

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CHAPTER 1

Introduction

The mountain pine beetle (MPB), *Dendroctonus ponderosae*, is native to the forests of western North America (Leatherman, Aguayo, & Mehall, 2007). Outbreaks of beetle infestations are natural ecological processes. However, there has been a severe and widespread epidemic of the MPB in the region (Colorado State Forest Service [CSFS], 2010; U.S. Forest Service [USFS], 2012d). In recent years, the MPB, along with several other species of bark beetles, have severely damaged coniferous forests in the western United States (US) and Canada.

The extent of the MPB infestation in Colorado and Wyoming has significant implications. It not only impacts federal and state forest service managers, but also wildlife managers, the recreation and tourism industries, private land owners, and the sustainability of livelihoods in proximity to forested areas. Affected natural processes include ecosystem services, including the quality of municipal, state, and national water resources. At various government scales, managers will develop specific management plans for fuel treatments, protecting values at risk, recreation, and other areas.

Prescribed fire is one fuel treatment method available to managers. It is defined as a fire intentionally ignited by management under an approved plan to meet specific objectives (National Wildfire Coordinating Group [NWCG], 2012a). Prescribed fires can be used to accomplish specific management goals, such as burning off excess vegetation in the forest. The purpose is to decrease the likelihood of large, potentially uncontrollable forest fires. Managers are interested in assessing the public's perceptions of prescribed fires to determine the level of agreement for specific management actions. Understanding these perceptions can help managers recognize when policies might be supported by the public, alert them when policies may run into

opposition, and help develop communication strategies designed to inform the public on potentially controversial strategies (Carroll & Bright, 2009).

Study Conceptual Model

The following conceptual framework was developed to examine how people think about prescribed fires and to assist managers in assessing, understanding, and incorporating the public's thought complexity toward prescribed fires into the management process. To discuss the broader implications of the research, the study author developed a concept map of the research process (Figure 1). It represents the theoretical research, the relationship between the components, and broader implications for agency management. The study's theoretical foundation of *integrative complexity* is placed within the model's framework. It is a continuous process of learning and adaptation, based on fire and social science research contributions, organizational and policy changes, and interaction with stakeholders. The concept map is the "So what?" aspect of the study.

Adaptive management is the management process used in this model. It is well-suited for complex situations possessing a high-degree of risk and uncertainty (Stankey, Clark, & Bormann, 2005). This investigation's conceptual framework uses the USFS as the managing agency. It should be noted, however, that other local, state, and federal management agencies may benefit from this research.

The model includes both component flows and conceptual links between several of the components. The components are discussed separately.

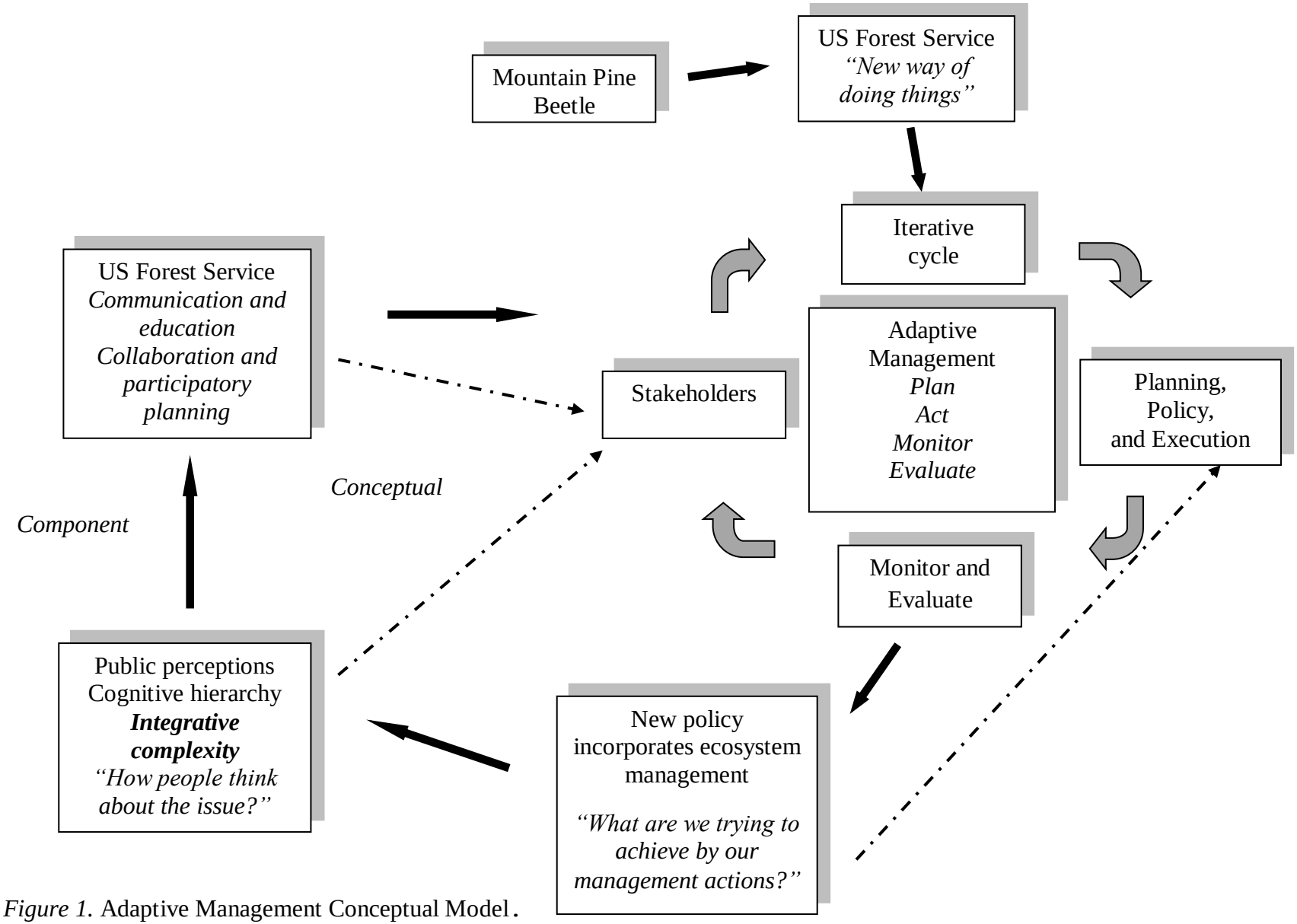

Figure 1. Adaptive Management Conceptual Model.

Mountain Pine Beetle

Limburg, O'Neill, Costanza, and Farber (2002) observe that an open system, such as an ecological one, will have driving forces moving in and out of the system's boundaries. In the case of this model, the MPB infestation provides an outside source which then prompts the system flow. Romme et al. (2006) observe that the current MPB infestation in Colorado and Wyoming is not unnaturally high, based on analysis of similar outbreaks in the past. It is a natural occurrence that is followed by re-development of the forest through ecological processes.

As with many ecological processes, the factors that control this outbreak are complex. Four interacting factors contributed to the outbreak: (a) long-term drought, which stresses trees and makes them more vulnerable to insects; (b) warm summers, which further stress the trees and may accelerate growth of the insects; (c) warm winters, which enhance survival of insect larvae; and (d) abundant food for the insects in the region's extensive and often dense forests. While not considered an emergency by Romme et al. (2006), the infestation has resulted in extensive mortality rates for lodgepole, ponderosa, and limber pine trees.

United States Forest Service

The USFS mission is to sustain the health, diversity, and productivity of the nation's forests (USFS, 2012c). The high mortality rates resulted in a changed landscape and increased both USFS and public concerns over forest health, a potential increase of the risk of wildfires, visitor safety in national forests, and other areas. There was recognition within the USFS, and particularly the service's Rocky Mountain Region, that a new way of doing things was necessary.

This reaction required a certain degree of intellectual and physical agility. Past history suggests that the character of the USFS, recognized for being a well-managed, responsive

organization, able to incorporate new missions and programs, contributed to this successful response (Clark & McCool, 1985; Rainey & Steinbauer, 1999).

Adaptive Management and Organizational Change

The USFS established an Incident Management Organization (IMO) to address the MPB infestation in Colorado, South Dakota, and Wyoming (USFS, 2012d). The IMO developed a multi-year plan to (a) reduce hazardous fuels and wildfire risk to the forest, homes, communities, and critical watersheds, and (b) reduce hazards to recreation and public infrastructure. The key aspect, from an organizational perspective, is that the IMO established a "theater of operations," which incorporated the affected forests. This structure erased USFS forest and district boundaries, allowing the IMO to serve as the focal point for project planning, prioritization, management, and assessment. This process demonstrated an adaptive approach to managing the situation.

Previous USFS use of adaptive management. The USFS previously implemented adaptive management for use in 1994 (Stankey et al., 2005). The adaptive management cycle is plan, act, monitor, and evaluate. It is well-suited for complex situations possessing a high degree of risk and uncertainty. Managers in the IMO faced a complex environment. The landscape is undergoing a major natural disturbance, with implications for ecosystems health (e.g., water supplies and forest regeneration). There was some professional disagreement and evolving knowledge about the relationship between the MPB and wildfire risk. Combined with the presence of an expanding WUI in the region, there was a certain element of risk (CSFS, 2011). Risk was also a factor in actual and perceived threats to people recreating in the national forest. Dead trees which fell could be a threat to individuals on trails and in campgrounds. A management system incorporating these factors was essential.

The adaptive management cycle is iterative. It completes the cycle and begins again when new information is presented, actions are evaluated, or feedback is received from stakeholders. Shortfalls may occur in two areas. Public and stakeholder participation is a key element which enhances the process. Framing questions and problems in the planning stage, resulting in a course of action, or policy, should, but does not always, include results of previous tests, experiments, and policy implementation. Policies must be implemented that encourage the development of flexible institutions capable of monitoring, evaluating, and taking corrective actions (McLain & Lee, 1996).

Ecosystem Management/Services Policy

Anderson (2006, p. 6) defines policy as a "relatively stable, purposive course of action followed by an actor or set of actors in dealing with a problem or matter of concern." Considering the context of this dissertation, the problem is the MPB infestation. It, in turn, is linked to both ecosystem and wildland fire management. These two management areas, found at the federal level, are linked by common policy which promotes management at the landscape or ecosystem level (Koontz & Bodine, 2006; WFEC, 2009). Barker (2005) notes the long conflicts within federal wildland fire policy between fire suppression and use of fire's natural process on the landscape.

From the study's perspective, prescribed fires complement both policy areas. Prescribed fires can be used to reduce hazardous fuels in the MPB IMO theater of operations. That same fire can also restore ecosystem health, contributing to re-generation of impacted forests. Of course, there will be various levels of scale for management actions, especially with a federal-level policy on wildland fire management.

The benefits provided to humans by a healthy ecosystem are captured in the concept of ecosystem services (Millennium Ecosystem Assessment [MEA], 2005). The practice of making decisions by considering the valuation of natural capital is not widespread in the USFS or other agencies. However, management objectives and practices suggest that intangible values are considered and cost-benefit analyses, though not formal, may be included in certain circumstances. Recreation opportunities in healthy forests can be considered an intangible. An example of cost-benefit analysis would be a prescribed fire that reduces fuel buildup in a certain landscape. This could possibly reduce the potential for a severe fire which would kill ground cover and damage the soil, leading to erosion. The erosion resulting from a high-severity fire may result in sediment and debris in a municipal water system.

Integrative Complexity Analysis

The study examined the impact of complex thinking on basic beliefs and attitudes toward prescribed fire and the relationship between them. This assessment included a quantitative analysis in three study locations in Colorado and Wyoming.

The quantitative analysis uses the *cognitive hierarchy theory* and *integrative complexity* as the theoretical foundations (Baron & Kenny, 1986; Carroll & Bright, 2009, 2010; Homer & Kahle, 1988; Rokeach, 1973; Tetlock, 1989; Vaske, 2008). Specifically, this analysis examined the moderating effects of integrative complexity on the relationship between basic belief indices and attitude toward prescribed fire.

Cognitive hierarchy examines values, value orientations (pattern of basic beliefs), attitudes, and norms in an effort to understand how these concepts influence behavior (Vaske, 2008). This study examined the relationship between values, basic beliefs, and attitudes and is illustrated by Figure 2.

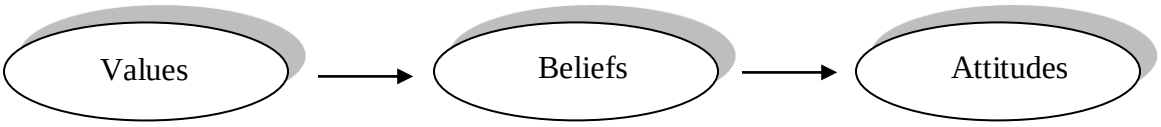

Figure 2. Value-belief-attitude model.

A moderator is a variable that affects the direction and/or strength of the relationship between an independent and dependent variable (Baron & Kenny, 1986; Vaske, 2008). Within this framework, moderation implies that the causal relationship between two variables changes as a function of the moderator variable. The moderation hypothesis is supported if the interaction path (Path *c*) is significant (Figure 3). There may also be significant main effects for the predictor and moderator (Paths *a* and *b*), but these are not directly relevant conceptually to testing the moderator hypothesis (Baron & Kenny, 1986). The research objective of using integrative complexity is to determine how people think about the issue of prescribed fires. This information is linked back to the adaptive management cycle by providing public and stakeholder feedback to the USFS.

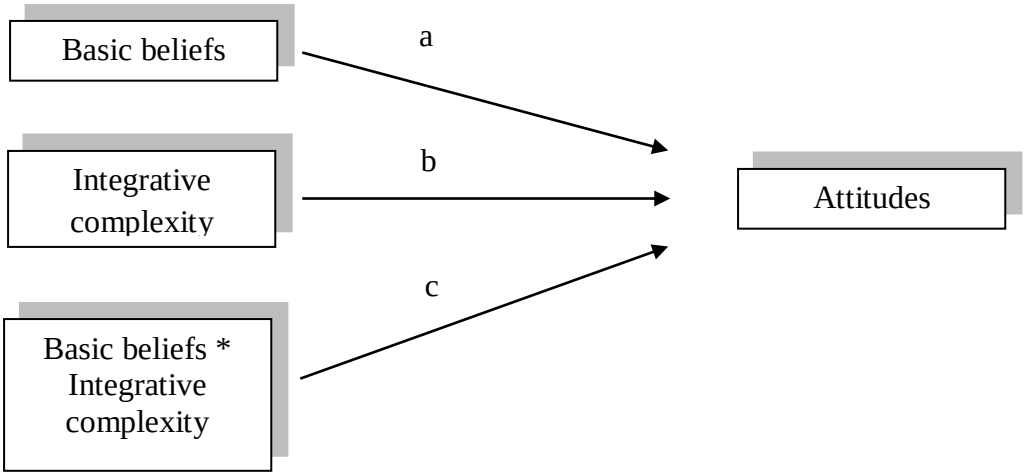

Figure 3. Integrative Complexity Moderation Model for Prescribed Fire Attitudes.

United States Forest Service Outreach Efforts

Natural resource managers recognize that the social sciences can be used to support the formulation of management decisions with accurate and timely information (Absher & Vaske, 2005; Allen et al., 2009; Bright & Newman, 2006; Bright, Newman, & Carroll, 2007; Clement & Cheng, 2011; McCaffrey & Winter, 2007). Understanding how the general public perceives a specific decision is critical for success in communicating and implementing management plans acceptable to the public (Burtz & Bright, 2007). As Knotek (2006) suggests, the decisions made by both managers and the public are influenced by their cognitive disposition. This includes value orientations, attitudes, and behavioral intentions. The information that is provided by the integrative complexity study allows the USFS to tailor various outreach efforts. These will include public communication and education, as well as collaboration and participatory planning (Jakes, 2007; Toman & Shindler, 2006). The analysis can contribute to a better understanding of how the public perceives prescribed fires.

This component then flows back into the iterative adaptive management cycle, and the system begins again. At the same time, the USFS considers the feedback it receives from public and stakeholder participation. Results and feedback are evaluated and changes are then made to subsequent actions.

Study Empirical Data

For the purpose of this study, this investigator examined empirical data found in an assessment of public perceptions of the MPB. The assessment, designed to gather data for the dissertation, also provided content for a descriptive report submitted to the USFS. Households in counties adjacent to three study areas, located in northern Colorado and southern Wyoming, were the target of this social science research. The first study area, designated "Front Range,"

was located in Colorado and comprised of Boulder, Clear Creek, Gilpin, Grand, Jefferson, and Larimer Counties. Jackson, Moffat, and Routt Counties in Colorado and Albany, Carbon, Converse, Laramie, and Natrona Counties in Wyoming comprised the second study area, "Northern." The final study area, "Central," was comprised of Garfield, Eagle, Pitkin, Rio Blanco, and Summit Counties in Colorado. These locations cover the area most impacted by the MPB outbreak in the region and allowed comparisons with previous research on related subjects. Time frame of the data collection was November, 2011, to January, 2012.

Statement of the Problem

The purpose of the investigation was to determine respondents' level of thought complexity toward prescribed fire and apply it to a conceptual framework in order to assist the USFS in developing prescribed fire-related policies, management actions, and communication strategies. There were several goals of the study that support this end state. The first was to further validate a recently-developed measurement tool for *integrative complexity* and apply it to a new research scenario (Carroll & Bright, 2010). Integrative complexity is a protocol for measuring a way of thinking. Based on the number of aspects about a problem people consider, it can describe the structure of individual's thoughts about dichotomous issues, over and above the content (Tetlock, 1989). The second goal was to identify respondents' level of complexity when they think about the issue of prescribed fire within the context of the MPB outbreak in northern Colorado and southern Wyoming. This provides information on how respondents think about prescribed fire and is valuable for agencies which have the mandate to incorporate public participation into management actions (Allen et al., 2009; Haas, 2003; McCaffrey & Winter, 2007). The final goal was to identify respondents' perceptions of the MPB and examine any demographic-related differentiation in integrative complexity.

Proposed Research Objectives

To examine the study goals, five research objectives were pursued. The first of these includes a demographic analysis of respondents. Previous research does not suggest a significant relationship between an individual's level of integrative complexity and demographics, such as age, gender, income, or education (Hunsberger, Lea, Pancer, Pratt, & McKenzie, 1992). The first proposed research objective was to:

R1: Determine whether demographics influence respondent levels of integrative complexity.

Previous research suggests that there is no relationship between integrative complexity and attitude direction. To examine this, the following research objective was proposed:

R2: Determine if respondents with positive attitude direction toward prescribed fire hold different levels of integrative complexity than respondents with negative attitudes.

This relationship is illustrated by Figure 4.

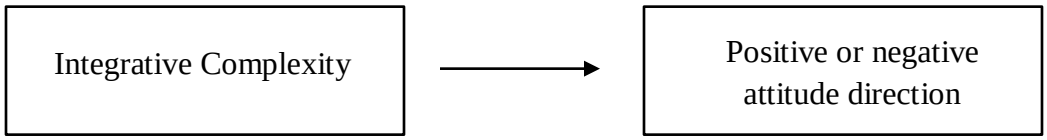

Figure 4. Proposed relationship between integrative complexity and positive or negative attitude direction.

Previous research does suggest, however, that there is a significant relationship between integrative complexity and attitude extremity. To examine this, the following research objective was proposed:

R3: Determine if respondents' extreme attitudes toward prescribed fire are characterized by different levels of integrative complexity than moderate attitudes.

This relationship is illustrated by Figure 5.

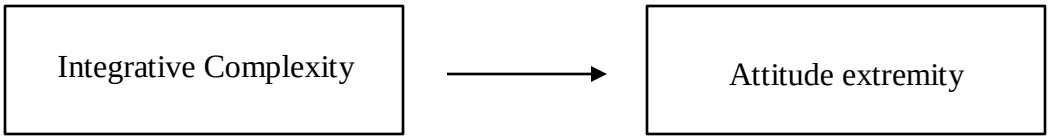

Figure 5. Proposed relationship between integrative complexity and attitude extremity.

In moderation analysis, it is highly desirable that the moderator variable is uncorrelated to the independent variables. This provides a clearly interpretable interaction term (Baron & Kenny, 1986). To examine this, the following research objective was proposed:

R4: Determine if there was a significant correlation between respondents' level of integrative complexity and wildland fire management basic belief indices.

The final research objective dealt with the study's moderation analysis. It examined whether integrative complexity affects the direction and/or strength of the relation between wildland fire management belief indices (independent) and prescribed fire attitude (dependent) (Figure 2). To examine this relationship, the following research objective was proposed:

R5: Determine if the relationship between basic beliefs about wildland fire management and attitudes toward prescribed fire are moderated by integrative complexity.

Delimitations

Several delimitations to this study need to be acknowledged. First, the sample population was limited to a random sample drawn from addresses provided by a commercial firm's statistical sampling software. The firm, Marketing Systems Group, holds a license for, and uses, the US Postal Service's Computerized Delivery Sequence File. This method of sampling limited the sample population to those persons with a valid US Postal Service city-style, rural route, post office box, or seasonal address. Second, the random sample was based on a county-level definition. For example, the sample for Larimer County, CO, was based on the county as a whole, with no design intent to obtain an equal percentage of rural, urban, or wildland-urban

interface respondents. Finally, this study's conceptual model incorporated integrative complexity into a USFS decision-making process using adaptive management (Stankey, Clark, & Bormann, 2004). Other management processes that may be used by various natural resource management agencies were not included in the scope of the inquiry. The author believes that including various management models in a conceptual model was beyond the reach of this study.

Limitations

The three locations found in this study are in northern Colorado and southern Wyoming. This study explored integrative complexity within the context of wildland fire management and the MPB in these specific locations. At the time of the study, various types of bark beetle infestation ranged from Alaska to the US-Mexican border (Nikifork, 2011). However, it would be inappropriate to generalize the results of this study to non-sampled populations or locations. There is an additional sample-related limitation. The sample population for this study included subjects with seasonal addresses. However, data analysis indicates that 97% of respondents identified their address as their primary residence. Specific reasons for the discrepancy between this anticipated element of study design and the study results were not explored. Therefore, it would not be appropriate to make any inferences about seasonal residents, as a separate sample group, in the MPB-impacted study locations.

Relevance of the Study

This study continues research of the relationship between the MPB and wildfires. Concurrently, agencies continue to identify appropriate forest management practices for MPB-impacted landscapes, incorporating tools such as prescribed fire. These same agencies must also educate and inform the public about prescribed fire, as well as include the public in the policy process. This study is relevant to this general situation in several areas.

Managerially, this study provides agencies a tool to use in developing communication strategies. If agencies understand the level of complexity with which the public views prescribed fire, the proper content can be developed for effective dialogue. For example, if one segment of the population conceptualizes a variety of arguments for and against prescribed fire, an agency can communicate with that group much differently than if that same population group simply did not accept fire on the landscape.

Professionally, this is a very dynamic time for fire social science research. The fire community recognizes the need for increased social science research and interaction between fire managers, fire behavior analysts, and social scientists (Kobziar et al., 2009). This study provides a template for an additional social science contribution to the fire community.

Socially, the interaction of wildfires, MPB, and people will continue for a period of time. As Romme et al. (2006) observe, it generally takes several generations for the development of new forests after a MPB outbreak. During that time, the WUI will continue to expand and there will be a necessary social component to widlland fire management decisions. This study can build upon, and contribute, to the previous social science research which has taken place.

Finally, this study is theoretically relevant for several reasons. First, it builds upon the previous research on integrative complexity conducted by Wallbaum (1993), Tetlock (1989), Burtz and Bright (2007), Carroll and Bright (2009, 2010) and others. Second, it validates a new research methodology developed by Carroll and Bright (2010), making the analysis of integrative complexity less burdensome and more applicable. Finally, the study applies the methodology to a new research scenario, building upon integrative complexity's previous application to wildland fire management and other natural resource management scenarios.

CHAPTER 2

Literature Review

This chapter reviews and discusses the literature pertinent to the dissertation's research objectives and conceptual structure. The references examined dealt specifically with the MPB, wildland fire and disturbance-driven landscapes, the theoretical framework of *cognitive hierarchy* and *integrative complexity*, adaptive management, and ecosystem management. The non-theoretical components are addressed due to their conceptual significance to the study. They link the theoretical cognitive hierarchy and integrative complexity research with the larger theme of incorporating the social sciences into natural resource management decisions (Allen et al., 2009; Cortner & Field, 2007). Initially, the review will examine the MPB and related wildland fire literature. Next, the theoretical frameworks of cognitive hierarchy and integrative complexity are discussed. Finally, adaptive management, as an iterative process, and ecosystem management are examined.

Mountain Pine Beetle

The mountain pine beetle (MPB), *Dendroctonus ponderosae*, is native to the forests of western North America feeding on ponderosa, lodgepole, and limber pines (Leatherman et al., 2007; Romme et al., 2006). Outbreaks of beetle infestations are natural ecological processes which have occurred repeatedly in the past. However, there has been a severe and widespread epidemic of the MPB in the region which has attracted a great deal of public attention (CSFS, 2010; USFS, 2012d). In recent years, the MPB, along with several other species of bark beetles, have severely damaged coniferous forests in the western US and Canada.

By 2010 in Colorado, the CSFS estimated that tree mortality from the beetle covered approximately 2 million acres, including all of the state's mature lodgepole pine and other forest

types (CSFS, 2010; Price, 2010). The USFS estimated that in Wyoming, the MPB had affected approximately 694,150 acres of lodgepole, limber, and ponderosa pine by 2010 (USFS, 2010). In 2009 alone, the infestation grew by 524,000 acres in the two states, with most new activity east of the Continental Divide in northern Colorado and the Snowy and Laramie Ranges of southern Wyoming. This has impacted more than 900 miles of trail, 3,200 miles of road, and 21,000 acres of developed recreational sites (USFS, 2011d). Statewide in Colorado, a 2011 aerial survey indicated that the total MPB infestation is 3.3 million acres, with the epidemic slowing down in many areas (USFS & CSFS, 2012). Another key area of concern is water. The major source of water in Colorado (68%) and Wyoming (53%) originates on national forest lands. Also, much of the water infrastructure, such as reservoirs, ditches, and pipelines, is also located on USFS property. In areas impacted by the MPB, changes to watershed processes are anticipated (USFS, 2008).

As with all ecological components, the reasons for the recent outbreak are complex. The severity of the current MPB epidemic can be attributed to overcrowded forests, the consequence of fire suppression, and prolonged drought conditions across western North America. Climate change has also been suggested as contributing to the outbreak (Price, McCollum, & Berrens, 2010). The result is a greater number of trees competing for less water. This leaves trees in a weakened or stressed condition and more susceptible to insects and disease (Taylor & Carroll, 2003). Romme et al. (2006) attribute the outbreak to four interacting factors: (a) long-term drought, which stresses trees and makes them more vulnerable to insects; (b) warm summers, which further stress the trees and may accelerate growth of the insects; (c) warm winters, which enhance survival of insect larvae; and (d) abundant food for the insects in the region's extensive and often dense forests.

Impacts of the Outbreak

Forests provide many products and services, such as timber, water runoff, livestock forage, plant and animal habitat, recreation opportunities, aesthetic landscapes, and biodiversity (Rosenberger & Smith, 1997). The extent of the MPB infestation in Colorado and Wyoming has significant implications for government agencies, communities, and individuals. For many residents of both states, the transition of certain forested areas from green to grey is the most recognizable manifestation of the MPB infestation. At the federal level, USFS managers will develop specific management plans in response to this situation. Taking into account the public's value orientations, attitudes, and preferences toward national forest goals, uses, and management activities are a matter of critical importance for the USFS (Allen et al., 2009; Clement & Cheng, 2010; McCaffrey, 2007). This process allows an improved integration of land management and public concerns and interests (Bright & Burtz, 2006). As suggested by McFarlane, Stumpf-Allen, and Watson (2006), knowledge is one of the best predictors for the public's attitude toward the MPB. An assessment of the public's knowledge and related attitudes is a key tool for USFS managers. When dealing with the public, one area of interest for USFS supervisors is the perceptions of individuals living in a disturbance-driven (e.g., wildfires and insects) landscape.

Although the MPB is always present at endemic levels, the size and severity of the current outbreak has caused concern relative to public safety and essential infrastructure (CSFS, 2010; USFS, 2011). There are also other impacts of the infestation. Price et al. (2010) suggest that an important consequence of the infestation is declining utility for residents of the wildland-urban interface (WUI). The WUI is defined as the area where structures and other human habitation intermixes with, or is adjacent to, natural areas (Stewart, 2007; University of Wisconsin-Madison, 2010). Declining utility is the reduction of the level of satisfaction derived

from goods and services. Specifically, beetle infestations lower utility by reducing the value of forest amenities and potentially increasing the risk of wildfires (Price et al., 2010; Romme et al., 2006).

This impacts both recreation and economics. Residents and visitors may be attracted to national forests by the scenery and recreational opportunities they provide. Several sources of information dealt with the hazards MPB-killed trees pose to visitors to national forests and national parks (McFarlane et al., 2006; National Park Service, n.d.; USFS, 2009). Agency intent is to inform visitors about potential risks at campgrounds, picnic areas, and along trials. Many agency efforts have been directed at removing or minimizing the threat. The MPB infestation may also lessen aesthetic or recreational satisfaction, potentially causing individuals and families not to visit (Buhyoff, Wellman, & Daniel, 1982; McFarlane, & Watson, 2008; Ministry of Forests [MoF], 2003; Price et al., 2010).

The economic impact of MPB infestation has been addressed from several perspectives. Canadian sources examined the MPB impact on the forest products industry (McFarlane et al., 2006; MoF, 2003; Parkins & MacKendric, 2007). This research focused on communities that primarily depend on surrounding forests for their economy. In certain instances, communities my actually benefit economically in the short-term, based on harvesting infested trees before their value diminishes. However, this depends on a viable wood products market. Many communities adjacent to national forests also see the economic potential of expanding biomass industries. One example, examined by Canadian researchers, is the use of surplus wood from MPB-infested forests for bioenergy (Mahmoudi, Sowlati, & Sokhansanj, 2009). They found that harvest and transportation costs, combined with supply logistics, are challenges related to forest biomass utilization. This research effort is also reflected by on-going, community-based studies by the

Colorado Forest Restoration Institute on short- and long-term economic opportunities for communities adjacent to MPB-infested forest landscapes (Colorado Forest Restoration Institute, 2010). Finally, Rosenberger and Smith (1997) conducted a literature review on the nonmarket economic impacts of forest insects, including the MPB. They found negative impacts on property values, both residential and commercial, recreation and aesthetic values, increased costs of mitigation, and financial loss. Their results reflect the integration of recreational, economic impacts, and disturbance-driven impacts.

Wildland Fire and Disturbance-driven Landscapes

One primary focus of this review is an examination of the literature that addresses the impact of MPB on living in a disturbance-driven landscape. This exemplifies the interaction of the MPB infestation with social considerations and consequences. In general, forest disturbances have profound economic, social, political, and ecological implications for people living, working, and recreating in and near forest landscapes. Values, interests, and concerns of local stakeholders should be incorporated into management strategies. This avoids costly conflicts and reduces the long-term impacts of forest disturbances (Flint, McFarlane, & Müller, 2009). As a component of this literature review, it is necessary to explain the concept of a natural disturbance. Natural, or ecological, disturbances are the dominant factor in defining composition and structure of forest ecosystems. Fires, insects, and pathogens are primary agents of disturbance and, under certain circumstances, can cause extensive tree mortality (Goyer, Wagner, & Schowalter, 1998). Baker (2009) identifies drought as another type of disturbance. The MPB infestation is readily apparent in this literature and the MPB is one example of a natural disturbance agent.

Wildland fire. A social component of the MPB infestation is an interest in a potential increase in wildfire susceptibility. This perceived threat has received a significant amount of public interest for the past several years (Pankratz, 2008). Bark beetle-caused tree mortality affects the quantity and quality of forest fuels and is assumed to increase fire hazard and potential fire behavior (Jenkins, Hebertson, Page, & Jorgenson, 2008). The National Wildfire Coordinating Group's (NWCG) revised definitions define a wildfire as an unplanned, unwanted wildland fire including unauthorized human-caused fires, escaped wildland fire use events, escaped prescribed fire projects, and all other wildland fires where the objective is to put the fire out. Wildland fire is now a general term describing any non-structure fire that occurs in the vegetation and/or natural fuels. The term wildland fire is no longer used to define a type of fire. There are now only two types of wildland fire, wildfire and prescribed fire (NWCG, 2010, 2011). Though still commonly used and easily identified by the public, the term prescribed burn is now considered an approved synonym for the official term, prescribed fire (NWCG, 2010).

Four common mitigation strategies can be implemented to reduce the wildfire risk. Two individual actions are establishing defensible space and firewise construction, while agency actions include prescribed fires and mechanical thinning (Absher & Vaske, 2005). A prescribed fire is any fire intentionally ignited by management, under an approved plan, to meet specific objectives, often fuel reduction (NWCG, 2010, 2012). The plan is an important consideration. It incorporates temperature, humidity, wind, moisture of the vegetation, and conditions for dispersal of smoke. Managers compare conditions on the ground to the plan before deciding whether to conduct the burn on a given day (NWCG, 2010; USFS, 2012a). These fires can replicate the benefits of wildfires on the landscape, assisting with the restoration of ecosystem health. Prescribed fires assist in maintaining biodiversity and reduce the risk to people and

property. Properly managed, they also cause far less damage to ecological processes than uncontrolled, severe wildfires (McLoughlin, 2011). Prescribed fires are called the right fire, at the right place, at the right time. Based on the plan's controlling parameters, they provide many positive benefits to ecosystem services (Neary, Ryan, & DeBano, 2005; USFS, 2012b).

As a disturbance agent associated with MPB infestation and tree mortality, fire has a natural place in the landscape. Pyne, Andrews, and Laven (1996) identify the fire regime as the interplay between fuels, weather, and topography, which primarily determines the pattern of fire in vegetation over time. Topography is constant, while fuels and weather can vary substantially over time and space. The term "fuels," including trees killed by MPB, refers to the living and dead biomass that is burnable under certain moisture conditions, varying by forest type, time of year, and disturbance history. Fuels generally occur as mosaics, rarely unbroken and continuous over large areas (Pyne et al., 1996).

Wildfire and MPB. Within this context, there has been research on how the MPB infestation adds to the fuel base. The USFS summarized the three stages in a beetle infestation life cycle and how each potentially contributes to increasing the fire hazard. During the first three years, the fine, dry needles on dead pine trees can easily ignite. From the third to tenth year, fire danger decreases after the needles fall from the trees. High winds may cause the toppling of dead trees, posing a danger to forest visitors. After this period, the majority of trees fall down, creating large, dense surface fuels. In certain forests, this may increase the risk for high intensity fire. Downed logs may also make it hard to access and control fires (USFS, 2009). Page and Jenkins (2007) suggest that MPB and its effects on lodgepole pine fuels resulted in drastic changes in fire behavior, increased rates of surface spread, fireline intensities, and crown fire potential, in both current and post-epidemic stands.

However, there is no agreement in the literature on the relationship between MPB and wildfires. Contrary to the previously-cited literature, other sources suggest that bark beetles, and their effect on fuel accumulation and subsequent fire hazard, are poorly understood. The interaction of western bark beetles, fuels and fire in forest systems is inherently complex and much remains unknown (Jenkins et al., 2008). Research by Romme et al. (2006) suggest that few scientific studies support the assertion that insect outbreaks set the stage for severe forest fires. Baker (2009) concurs, observing that the limited available evidence suggests that fires will not be substantially changed in intensity or extent. The results of recent research by Simard, Romme, Griffin, and Turner (2011) suggest that fires in subalpine conifer forests are mainly driven by climate.

Hicke, Johnson, Hayes, and Preisler (2012) conducted a literature review on the effects of bark-beetle caused tree mortality on wildfires. They found that published studies suggest that bark beetle outbreaks can affect fuels and fire behavior. The type of change depended on the research question asked, time since the outbreak, and the fuel or fire characteristic of interest. Because of this, any generalization of fire effects are unwarranted. A Joint Fire Science Program (Wells, 2012) summary makes a similar observation. Namely, the fire-beetle relationship is too complicated to yield easy management decisions. Managers must consider their objectives in light of the ecological, economic, and social opportunities and constraints within their management scope. They also must consider the ecological drivers of both beetle epidemics and wildfires. The summary concurs with the observations of Romme et al. (2006) in that climate change complicates the understanding of wildfire and beetle epidemics, both of which appear to be responding to a warming climate.

Taking this ongoing research into account, management plans that consider bark beetle and fire interactions can provide managers with better guidance to meet resource objectives, reduce treatment costs (e.g., mechanical thinning and prescribed fires), minimize adverse ecological impacts, and, from a social perspective, avoid potential controversy (Jenkins et al., 2008).

Solving the problem of fire within the WUI may never be complete because of continual changes in social and biophysical systems associated with population growth, cultural change, fuel and climatic shifts (Gill & Stephens, 2009). Addressing the implications of fire requires effective and targeted management. Carroll, Blatner, Cohn, and Morgan (2007) refer to the fire problem as being a result of a complex mix of physical, ecological, economic and social developments.

Social aspects of disturbance. Examining the insect, itself, as the disturbance agent, the literature suggests a community-level analysis may be appropriate to study this natural disturbance. The socioeconomic and environmental features of local places (community context) influence the relationship between humans and their physical environment. Communities, especially those centered on the use of natural resources, form a primary backdrop for the study of human-environmental interactions (Qin & Flint, 2010). Their research in Colorado suggests that community factors, such as local beetle-caused tree mortality and socio-economic levels, influence participation in beetle-related activities. These activities included removing beetle-killed trees from personal property and attending a beetle task force meeting, among other actions.

The MPB infestation resulted in rapid ecological change and major challenges for forest-based communities and economies. This can be framed in terms of vulnerability and responses

(Parkins & MacKendrick, 2007). They suggest that the social science literature identifies vulnerability as a state or a process, rather than a set of biophysical impacts resulting from a particular event and states that adaptive capacity is the ability of a system to adjust to, or cope, with stress. Flint and Luloff (2005) suggest that the literature on natural resource based communities, disaster, and risk has identified a wide array of biophysical and socioeconomic factors influencing human response to forest ecosystem disturbance. While Parkins and MacKendrick (2007) suggest that community risk is a combination of social, economic, and biophysical settings, Qin and Flint (2010) suggest that communities respond to insect disturbances and forest management in different ways, involving social, cultural, economic, and environmental factors.

It is important to note that communities often differ in perceived impacts and risks and relationships with land managers (Flint et al., 2009). Each community is different regarding the degree to which it depends on forestry, recreation, or other economic drivers. The USFS conducted several studies which concluded that greater economic diversity, community autonomy and leadership, combined with lower dependence on the forest industry, contribute to greater community resilience (Harris, McLaughlin, Brown, & Becker, 2000). These social assessments reflect the importance of incorporating social science research into management actions.

Cognitive Hierarchy and Integrative Complexity

Natural resource managers recognize that the social sciences can be used to support the formulation of management decisions with accurate and timely information (Absher & Vaske, 2005; Allen et al., 2009). Understanding how the general public perceives a specific decision is critical for success in communicating and implementing management plans acceptable to the

public (Burtz & Bright, 2007). As Knotek (2006) suggests, the decisions made by both managers and the public are influenced by their cognitive disposition. This includes value orientations, attitudes, and behavioral intentions. Due to the often controversial and complex nature of many natural resource issues, including wildland fire management, managers can benefit from not only what the public thinks, but also how the public thinks about those issues. Measuring *integrative complexity* can assist managers in understanding how people think (Bright & Barro, 2000; Burtz & Bright, 2007, Carroll & Bright, 2009, 2010; Hunsberger et al., 1992; Tetlock, 1989).

Definition of the Concept

Integrative complexity is a measure of how complexly people think about an issue (Carroll & Bright, 2009; Tetlock, 1989). Carroll and Bright (2010) also suggest that it is useful for examining dichotomous issues. The concept focuses on the structure of thoughts, or beliefs, rather than the content of those beliefs (Bright & Barro, 2000; Carroll & Bright, 2010; Tetlock, 1989). Tetlock (1989) defines integrative complexity in terms of two cognitive structural variables. These are *differentiation* and *integration*. Differentiation refers to the number of distinct characteristics or dimensions of a problem or issue that an individual takes into account during decision making. Low differentiation reflects an individual's ability to only see one side of a topic. Individuals who can accept two or more dimensions to an issue demonstrate higher levels of differentiation (Bright & Barro, 2000; Carroll & Bright, 2009, 2010; Tetlock, 1989). A highly differentiated approach would potentially include contradictory aspects of an issue. An example would be the role of fire on the landscape. An individual can understand that there are benefits, such as reducing fuels and restoring healthy ecosystems. At the same time, the same individual may recognize that there are negative aspects, such as the risk to firefighters and structures, as well as the release of potentially harmful particulates in smoke.

Integration refers to the development of complex connections among the differentiated characteristics (Bright & Barro, 2000; Carroll & Bright, 2009, 2010; Tetlock, 1989). The complexity of integration depends on whether the individual perceives the different characteristics as operating in isolation (low integration), in first-order or simple interactions (the effects of A on B depend on levels of C, moderate integration), or in multiple, contingent patterns (high integration). A "trade off" is an example, such as how much smoke is acceptable during a prescribed fire that reduces fuels (Tetlock, 1989). It is important to note that an adequate amount of differentiation is a necessary condition for integration (Bright & Barro, 2000; Carroll & Bright, 2010; Tetlock, 1989). Wallbaum (1993) also suggests that integrative complexity is both a personality trait, based on the range of information processing available to an individual, and a temporary state in response to the situation. This was also suggested by de Vries and Walker (1987), who found that integrative complexity varies among individuals and is often a function of the situation. Related to this, Hunsberger et al. (1992) suggest that the ability to process complex information is based on personality traits, including intelligence and ideology. They also suggest that a higher complexity response can result when an individual is presented with complex information.

Integrative complexity and cognitive study. There is a link between integrative complexity and other fields of cognitive study. Cognitive theory allows the examination of the concepts underlying the process of human thought to action, such as values, attitudes, and norms, and examines the relationships among them (Fishbein & Ajzen, 1975; Vaske, 2008; Vaske & Donnelly, 1999). Previous research supports the importance of environmental and natural resource-based values orientations in attitude prediction (Bright & Barro, 2000; Bright & Manfredo, 1996; Vaske & Donnelly, 1999). For example, Bright and Manfredo (1996) and Burtz

and Bright (1998) found that the most important predictor of attitudes toward wolf reintroduction were the orientation of values related to the role of wolves in society.

Cognitive Hierarchy

The *cognitive hierarchy theory* assists in explaining an individual's willingness to support various natural resource management strategies. This theory suggests that behavior, although directly influenced by specific perceptions related to that behavior, may ultimately be connected with the values people hold (Bright & Burtz, 2006; Homer & Kahle, 1988; Manfredo, 2008). Fundamental values, not focused on specific objects or behaviors, are the foundation of the cognitive hierarchy. They represent desirable end-states and modes of conduct (Bright & Burtz, 2006; Homer & Kahle, 1988), such as freedom and responsibility. As Rokeach suggests (1973), values are guides and determinants of social attitudes and ideologies on the one hand and of social behavior on the other.

Basic beliefs comprise the next level of the hierarchy, representing a domain of interest. The pattern of basic beliefs, known as value orientations, represents the application of fundamental values to concrete issues, such as wildland fire management (Bright, Vaske, Kneeshaw, & Absher, 2003). Value orientations impact individual behavior by guiding beliefs, attitudes, and norms specifically related to that behavior (Bright & Burtz, 2006; Manfredo, 2008).

Attitudes are cognitive tendencies to respond either favorably or unfavorably toward a specific object or behavior (Eagly & Chaiken, 1993; Vaske & Donnelly, 1999). In turn, attitudes and norms then influence behavioral intentions and behavior (Manfredo, 2008; Vaske, 2008). McFarlane et al. (2006) suggest that attitudes toward natural resource management issues are influenced by several factors, including (a) an environmental worldview, (b) knowledge and

salience of the issue, and (c) sociocultural influences. Attitudes toward a management issue influence judgment of acceptable management and policy options.

Integrative complexity and the cognitive hierarchy. Integrative complexity has been found to be related separately to both values and attitudes (Carroll & Bright, 2009). Tetlock (1989) suggested that high levels of integrative complexity are linked to greater inclusion of fundamental values in guiding thoughts about an issue. Regarding attitudes, Eagly and Chaiken (1993) suggest that attitudes are described in terms of direction of their contents and magnitude. The direction of the evaluation of an attitude toward an object or behavior is either positive or negative (Eagly and Chaiken, 1993; Vaske & Donnelly, 1999). Previous research has not suggested a relationship between attitude direction and integrative complexity (Carroll & Bright, 2009; Burtz & Bright, 2007; de Vries & Walker, 1987). Another attitude characteristic is that they are held with varying levels of extremity.

Previous research suggests that attitudes may be formed as a consequence of the differentiation and integration of dimensions of, and perspectives on, information relevant to a particular domain (Burtz and Bright, 2007; de Vries & Walker, 1987). Attitudes that are structurally simple are expected to be more categorical. The more complex the attitude, the broader the range of information that is perceived as relevant. Previous research suggests that moderate belief systems were characterized by more complex belief systems regarding an attitude object than were extreme attitudes (Burtz & Bright, 2007; Bright & Manfredo, 1996; Linville, 1982). More moderate attitudes are linked to higher levels of integrative complexity. This was supported by the findings of Carroll and Bright (2009), who found that individuals who recognized the tenability of competing sides to an issue are more likely to have more moderate attitudes about the topic than those who view the same issue from one perspective (Bright &

Barro, 2000; Burtz & Bright, 2007) . As Tetlock (1989) observed, a higher level of integrative complexity was associated with a pragmatic, open-minded, and nonpartisan worldview.

Considering the complexity with which people think about a natural resource management issue can contribute to greater understanding of public perceptions regarding proposed or subsequent strategies and policies (Burtz & Bright, 2007). Carroll and Bright (2009) suggest that people who think more complexly about an issue should be more willing to consider the benefits of management approaches that are different than those of which they generally approve. They also suggest that integrative complexity may act as a moderator between certain values and attitudes (Carroll & Bright, 2009). As a moderator, integrative complexity measurements would affect the direction and/or strength of the relationship between value orientations/basic beliefs and attitudes (Baron & Kenny, 1986; Tarrant et al., 1997; Vaske, 2008).

Evolution of the Concept and Observations

Wallbaum (1993) suggests that integrative complexity theory evolved from Kelly's (1955) earlier work on the theory of personal constructs. Kelly's original work then formed the foundation for the conceptual systems theory, developed by Harvey, Hunt, and Schroder (1961) and followed sequentially by several other theories. These were conceptual complexity (Schroder, Driver, & Streufert, 1961), interactive complexity (Siegfried & Streufert, 1968), and eventually, integrative complexity (Suedfeld, Tetlock, & Streufert, 1992).

Tetlock's original research focus was on the nature of the relationship between political ideology and cognitive style (Tetlock, 1989). His research included content analysis of the policy statements of political elites, including U.S. Senators and Supreme Court Justices, British parliamentarians, and Soviet Politburo members. Wallbaum (1993) also examined the

relationship between integrative complexity and international crises from the perspective of political decision making.

Literature reviews by Burtz and Bright (2007) and Carroll and Bright (2010) identified similar political and non-political research. In the political arena, subjects included: (a) the integrative complexity of 16 leaders before, during, and after seven international crises; (b) Middle East leaders during the first Persian Gulf crisis; (c) arguments used in student political groups; and (d) the debate over slavery in the pre-Civil War United States. Non-political subjects included (a) the integrative complexity of the U.S. public's attitudes toward nuclear weapons, (b) the integrative complexity arguments of "pro-choice" and "pro-life" abortion advocates in the U.S., and (c) the effects of experiential learning, service learning, and technology in the classroom on integrative technology.

Observations of integrative complexity. Based on the research, Tetlock (1989) made several conclusions. His first was that his analysis allowed him to observe that cognitive indices were independent of the content of the arguments analyzed. Second, regarding a highly integrative complex politician, Tetlock observed that he or she would deemphasize the differences between major political parties, be tolerant of opposing viewpoints, think about issues in relatively non-ideological terms, and be unconcerned with assigning blame for societal problems. Related to this point, Tetlock observed that ideology would be influenced by the issue and situation during reasoning. Cognitive complexity or simplicity may not consistently be identified with political ideology. This was supported by the next conclusion. People reported more integratively complex thoughts to the degree the issue activated conflicting values that were important in their value hierarchy or close to being important. Finally, Tetlock concluded that policymaking roles encourage a higher level of integrative complexity. A policy maker

would have to understand all aspects of a problem or issue, even those with which he or she would fundamentally disagree.

Wallbaum (1993) concluded that integrative complexity was a useful tool for examining political decision making. He links integrative complexity with an individual's ability to be a "cognitive manager," responding to specific situations with an appropriate level of integrative complexity. In general, Wallbaum found that moderation was a dominant factor in crisis or conflict situations requiring agreement and cooperation, due to higher levels of integrative complexity. Interestingly, he also cited previous research that found in situations of "group think" or high stress, the level of complexity fell (Wallbaum, 1993).

Development of the Integrative Complexity Scale

Previous measurement of integrative complexity. The measurement of integrative complexity has also evolved. Traditionally, measurement of integrative complexity used either an existing text or generated a new text through a Sentence (later a Paragraph) Completion Test (PCT) (Carrol & Bright, 2010; Wallbaum, 1993). Wallbaum also states that spoken material could be coded. With the PCT, respondents write an essay about an issue, describing attitudes and beliefs. Each essay is scored analyzed by several raters for differentiation and integration. Integrative complexity is measured on a 7-point scale, ranging from 1 (lowest score) to 7 (highest score). Scores of 1 represent low differentiation and integration, scores of 3 represent moderate differentiation and low integration, scores of 5 represent moderate differentiation and integration, and scores of 7 represent high differentiation and integration (Tetlock, 1989). Intermediate scores of 2, 4, and 6 can be assigned if raters have difficulty deciding on a score (Carroll and Bright, 2010). At least two researchers are required to read and score every essay. Wallbaum (1993) observes that scores of 7 are quite rare and, in general, most scored materials

are low in integrative complexity. Carroll and Bright (2010) provide specific descriptions of the scores:

1 = No differentiation, the issue is seen in only black and white terms.

3 = The individual acknowledges at least two viewpoints, and there may be positive and negative aspects of each.

5 = The individual acknowledges not only multiple viewpoints, but that there is a moderate level of interactions and tradeoffs among the alternatives.

7 = Suggests that the individual also has deeply held basic values between the alternative issues.

Limitations to the previous measurement. Carroll and Bright (2010) identified four drawbacks that have been identified with this scoring methodology. First, the measurement process can be quite time consuming and requires significant effort by both the respondents and raters. The raters must rely on the *Manual for Coding Integrative Complexity* (Wallbaum, 1993). This has also been found to be a factor with low response rates in previous studies (Bright & Barro, 2000). The second factor is related to how well the respondents understand the directions for completing the survey. Respondents must understand to include opinions, valuations, or judgments. The third item to consider is that the scoring process is quite time consuming. Not only do the raters have to read each essay, they must discuss scores and their reasons for giving that score. Finally, the qualitative nature of the research makes it unfeasible to use on a large scale. This restricts the generalizability of the results.

Development of the Integrative Complexity Scale. To address these shortfalls, Carroll and Bright (2009, 2010) developed the Integrative Complexity Scale. The intent in doing so was to overcome the limitations found in the PCT. The scale was developed to measure differentiation

and integration. Differentiation is conceptualized as the extent to which a respondent recognizes alternative sides to an issue. In the traditional PCT model, the number of positive and negative statements about an issue were counted. High differentiation was indicated by an equal, or near equal, number of arguments for and against. In the scale method, respondents list the number of positive and negative arguments. Differentiation is measured as a value between 0 and 1, based on the ratio created by the number of arguments "for" versus arguments "against" the issue. The smaller number is divided by the larger to obtain the integration score. A value of zero reflects no differentiation and a value of 1 reflects the highest level of differentiation. For example, in a theoretical study, a respondent could provide up to five arguments for both "for" and "against." The respondent provided four answers "for" an argument and three "against." The differentiation ratio would be .75.

Integration is conceptualized as how the respondent recognizes interrelationships between the different sides of the issue and is linked to the relative strength, as perceived by the respondent, of the arguments on both sides. It is the relative consistency in the perceived strength of the "for" versus "against" arguments. The score is also a ratio between 0 and 1. The smaller mean is divided by the larger mean to obtain the integration score. To continue the example, the respondent could identify the weakness or strength of the arguments by using a scale with "1 = Extremely Weak" and "7 = Extremely Strong." If the respondent mean score for the "for" arguments was six and the mean score for the "against" was three, the integration score would be .50.

The overall integrative complexity score is the product of the differentiation and integration scores. The final calculation would also be a value between 0 and 1. In this example, the overall integrative complexity score would be .75 x .50 = .375 or .38. Equal weight is given

to both components, which is consistent with the traditional method of measurement using the PCT. Carroll and Bright (2010) tested the scale and found that there was a high correlation with the PCT and that the scale appears to be a functional substitute. They observe that it isn't an exact measure of integrative complexity, but a measure that seems to reflect and correlate well with the results obtained from the traditional PCT scoring methodology. In related research, Carroll and Bright (2009) did observe that further research in the scale's structure would be appropriate. For instance, determining which type of leading question should be used for the differentiation section, to ensure that the different dimensions are being identified. They also recommend potentially using different scales to measure integration. Instead of "strong" or "weak," perhaps use "important/not important" or "true/untrue." This could provide a better evaluation, based on the research objectives.

Advantages to the new methodology. There are several advantages to the new scale which address the drawbacks discussed with the PCT. It is an easier measurement tool to use, compared to the traditional PCT. The new method only requires one researcher to compute the scale values. Research bias is not introduced because the researcher simply identifies the respondent's number of positive and negative statements, as well as the respondent's perceived strength of each argument. The burden on both respondents and researchers is lowered. As a quantitative tool, it can be applied to a larger statistical analysis. The scale can also be used to further research the relationship between integrative complexity and the various components of the cognitive hierarchy. For instance, similar to research previously mentioned, additional studies can be conducted examining the role of integrative complexity as a moderator. The scale has direct application to research in the human dimensions of natural resources and natural resource management.

Integrative Complexity and Natural Resource Management

In human dimensions-related research, several previously mentioned studies incorporated measurement of integrative complexity. Carroll and Bright (2009) examined whether the relationship between value-laden basic beliefs about wildland fire management and attitudes toward prescribed fires are moderated by integrative complexity. This is similar to research conducted by Tarrant et al. (1997), which assessed moderating and mediating effects in the value-attitude relationship dealing with wildlife species protection. Burtz and Bright (2007) examined public attitudes toward wildfires and Bright and Barro (2000) conducted research on attitudes toward plant and wildlife protection. Similar to Hunsberger et al.'s (1992) observation about an individual's response to complex material, Bright and Barro (2000) cite research by Bright and Wyche (1998) on how coursework in environmental education affects how college students view the Endangered Species Act (ESA). Students who took coursework in environmental education had more complex reasoning on the EPA and related tradeoffs than those who had not.

Applicability to natural resource management. These research examples suggest that the concept of integrative complexity is an appropriate tool for natural resource managers to use. Many aspects of natural resource management are complex and it is critical for managers to understand the public's perceptions and ability to grasp the various levels of complexity. Managers are operating in an environment that quickly changes and many issues have multiple facets, depending on an individual's perspective. Implementing a policy, for instance, requires a shared understanding of the problem and agreement on a course of action to resolve it. A manager will have to be aware of multiple ways to view an issue and be prepared to address them within his or her organization, with collaborative partners, and the public. Public

participation in the process is essential. For example, in wildland fire management, a manager will have to deal with differing perspectives on resource objectives and priorities, ecological implications, safety of wildland firefighters and residents, and other considerations.

The use of integrative complexity allows managers to understand people's level of intricacy on understanding issues (Burtz & Bright, 2007). As Carroll and Bright (2009) suggest, understanding the public's perceptions of an issue can help agencies recognize when policies might be supported by the public, alert agencies when policies may run into public opposition, and help agencies develop information and outreach programs to gain public support for potentially controversial strategies. With the public's support, agencies can manage more efficiently, spending time and money on resources and programs, not on legal battles and policy adjustments.

McFarlane et al. (2006) suggest that the social aspects of natural disturbance in protected areas have not received the same amount of research attention as other subjects. Their research indicates that the literature on protected areas is primarily focused on the effects of wildfires or prescribed fires on recreation and non-market values and acceptance of fire policies. However, understanding stakeholders' attitudes toward natural disturbance, acceptance of managing natural disturbance, and the factors influencing these are important factors necessary to comprehend the social aspects of the situation (McFarlane et al., 2006). The following section discusses one management technique in disturbance-driven landscapes.

Adaptive Management

The mission of the USFS is to sustain the health, diversity, and productivity of the nation's forests and grasslands to meet the needs of present and future generations (USFS, 2012c). Since the service's founding in 1905, it has successfully responded to numerous

challenges related to its management responsibilities. One contributing factor has been the ability of the USFS to incorporate new missions and programs into its repertoire (Clark & McCool, 1985). It has also been recognized for traditionally being a well-managed, responsive organization (Rainey & Steinbauer, 1999).

Agency response to the MPB. Currently, the mountain pine beetle infestation provides an opportunity to examine how the USFS is responding to a significant, focusing event (Kingdon, 2003). Due to extent of the outbreak and potential implications for fire management, recreation, and forest-related economic considerations, the USFS responded by implementing a specific management tool. The Bark Beetle Incident Management Organization (IMO) was created in 2004 to address the MPB outbreak in Colorado, Wyoming, and South Dakota (USFS, 2012d). These are states within the USFS' Rocky Mountain Region. There are two important features of the IMO's approach. One was to designate the outbreak as an incident, implying a focused response in the context of statutory and policy requirements. The other was to create a "theater of operation," including the affected forests. This theater erases USFS district and forest boundaries for the purpose of MPB mitigation, allowing the IMO to identify, prioritize, manage, and implement project tasks across landscapes (USFS, 2012d).

As a planning document, the IMO developed and used the *Bark Beetle Incident Implementation Plan (2007 to 2011)*. The plan provided a strategy, with a detailed, multi-year project schedule to address the impacts of the MPB infestation. It was routinely updated, based on funding, emerging information, and other factors. The projects focused on forest vegetation management, wildfire hazard reduction, and prevention and mitigation actions for recreation and public infrastructure, such as trails, recreation sites, and power lines. The plan also provided information necessary to inform the public and develop collaborative opportunities across

different land ownerships (USFS, 2007). The USFS *Western Bark Beetle Strategy*, released in July, 2011, provides continuity to the 2007 implementation plan. It identifies how the service will respond to the bark beetle epidemic over the next five years and prioritizes treatments into the three main goals of human safety, recovery, and resiliency. One on-going collaborative partner in the process is the Colorado Bark Beetle Cooperative, a place-based organization addressing the environmental, social, and economic impacts of the bark beetles on high-altitude forests (Northwest Colorado Council of Governments [NWCCOG], 2011).

The IMO plan was developed in response to the recent MPB infestation and to meet public expectations (USFS, 2007). Wildland fire management was an area of emphasis in the plan. While there is some professional debate whether insect activity will cause a fire to be more severe than it would otherwise, efforts to reduce the impacts of insects and fires are warranted in many areas (Baker, 2009; Jenkins et al., 2008; Hicke et al., 2012; Romme et al., 2006).

Anderson (2006, p. 6) defines policy as a "relatively stable, purposive course of action followed by an actor or set of actors in dealing with a problem or matter of concern." Pyne (2007) made the observation that fire policy and fire sociology are the study of how, granted fire's physical properties, people should use fire and how they should protect themselves from its threats. Stephens and Ruth (2005) observe that the "forest-fire" policies of U.S. Federal agencies have evolved from the use of small U.S. Army patrols in the newly created National Parks to diverse policy initiatives and institutional arrangements that affect millions of acres of forests.

Limited steps taken before 1988 to reintroduce fire into the appropriate landscapes were generally stopped due to public and policymaker response to specific, high-visibility wildfires (Barker, 2005; Dombeck, Williams, & Wood, 2004). However, severe fires within the last decade have made it obvious that attempts to control fire in the fire-adapted ecosystems of the

western US are failing (Wise & Yoder, 2007). Dombeck et al. (2004) state that for wildland fire policies to be effective, they must be specific to local forest conditions and adaptable to new information about the natural environment and changing social conditions.

The ability of the USFS to establish the IMO and execute the related strategic plan suggests the service's inherent capability to respond to external events, while operating within statutory and policy guidelines. As Dombeck et al. (2004) observed, the service demonstrated that the management process can adapt to a fluid, uncertain environment. Within the larger context of federal wildland fire policy, the literature suggests that an adaptive management approach is appropriate.

Adaptive management and organizational change. Fire management is transitioning from an era dominated by fire suppression to one where fire use and suppression are equally viable management options. Fire has increasingly been incorporated into land-management programs as a component of ecosystem restoration and/or maintenance, for fuels management, and for protection against the negative effects of wildfires on human and biological communities (Kobizar et al., 2009). The *1995/2001 Federal Wildland Fire Policy* states that fire is a natural process and will be integrated into land and resource management plans and activities on a landscape scale, and across agency boundaries (Wildland Fire Executive Council [WFEC], 2009). The recent *National Cohesive Wildland Fire Management Strategy* reflects this policy by adopting the following vision, "To safely and effectively extinguish fire when needed; use fire where allowable; manage our natural resources; and as a Nation, live with wildland fire" (Wildland Fire Leadership Council [WFLC], 2012, p. 1). This policy directive and implementing strategy provide an opportunity to develop adaptive management practices, which are well-suited for landscape-scale management. Wise and Yoder (2007) conducted a literature review of

organizational learning and adaptive management in a wildland fire context. They suggest adaptive management is appropriate for the management requirements and is a valuable mechanism for incorporating lessons learned.

McLain and Lee (1996) suggest that adaptive management appeals to scientists and policy makers concerned with large-scale ecological systems, ranging from landscapes to river basins. Complex interactions occur at this larger scale, both biophysical and social. There is an uncertainty created by interactions at larger scales, and policies must be implemented that encourage the development of flexible institutions capable of monitoring, evaluating, and taking corrective actions (McLain & Lee, 1996). Tompkins and Adger (2004) observe that in dealing with uncertainty, management actions need to be iterative, flexible, and inclusionary. They must also take into account the technological, institutional, and management options that are available to individuals and communities.

Adaptive management process. The USFS adopted an adaptive management process for the 1994 Northwest Forest Plan (Stankey, Clark, & Bormann, 2005). Based on the complexities of the situation, the service found it to be an attractive strategy to use in situations where a high degree of uncertainty exists. As identified in the literature and adopted by the service, it is a four-phase cycle (Figure 1). In the first phase, plans are framed, based on existing knowledge, organizational goals, and current technology. In the second, actions are initiated. Phase three involves monitoring results of those actions, and in phase four, modifications are initiated. The process can then reinitiate, based on emerging knowledge and experience which are incorporated into new plans (McLain & Lee, 1996).

Several key elements of the process must be highlighted. There is a deliberate aspect to framing the questions and problems, conducting the tests and experiments, critically examining

the results, and reassessing the policy context that formed the basis for planning. Stakeholder participation is another key element of the process. The deliberative process is generally where a shortfall occurs in this management strategy. However, the process, as practiced, successfully

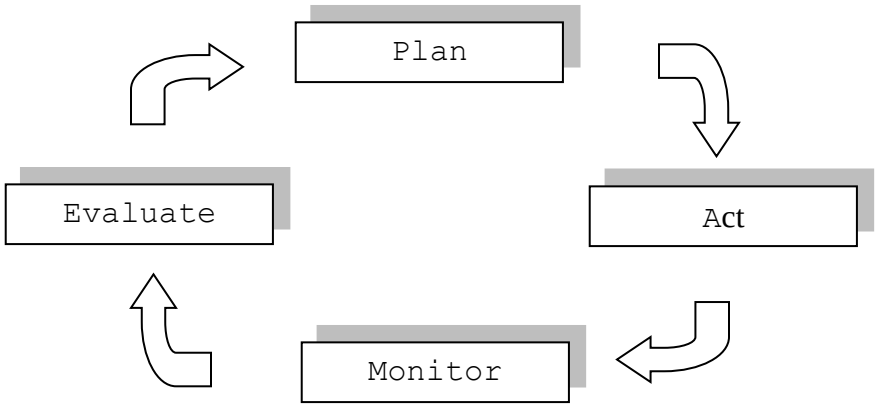

Figure 6. Adaptive Management Cycle. Adapted from Stankey, Clark, and Bormann (2004).

incorporates incremental adjustments in management actions (Stankey, Clark, & Bormann, 2004).

The concepts of risk and uncertainty are linked to adaptive management (Wise & Yoder, 2007). Although agencies are often adverse to risk, managers must support this process in order to address natural complexity and change at the larger, landscape scale (Stankey et al., 2005; Dombeck et al., 2004). This is also a challenge, based on the nature of an agency's responsibility to provide predictability and products to both Congress and constituents (Koontz & Bodine, 2008). This can be seen in the MPB IMO work, which must incorporate some degree of scientific disagreement and uncertainty regarding the fire risk in MPB-affected forests. The

IMO's plan implementation, based on current knowledge and local assessments, is being modified as new information is incorporated.

Adaptive management has also been identified as a critical component in management at the landscape, or ecosystem, level. Adopted by the USFS in 1994, ecosystem management was the result of recognition that a focus on a whole ecosystem is the appropriate scale to manage increasingly complex natural resource problems (Koontz & Bodine, 2008). In addition to adaptive management, Koontz and Bodine (2008) identify several other components, including collaboration with stakeholders, interagency collaboration, integration of scientific information to manage areas holistically across multiple resources and hierarchical levels of ecological systems, integration of social and economic information into management decisions, and preservation of ecological processes. The interrelationship between ecosystem management, current wildland fire policy, and the MPB IMO's work is apparent.

Organizational change. Linked to the ability to adapt to situational flux is the capacity of an organization to change. Pettigrew, Woodman, and Cameron (2001) state that an analysis of organizational change must link context with action over a period of time. Clarke and McCool (1985) observe that the USFS has been able to constantly evolve, based on a permanent mission which adapts to statutory and policy change, as well as changing public priorities. They credit this to the USFS being given a broad mandate to manage, conserve, use, and develop national forests and grasslands. Rainey and Steinbauer (1999) concur, suggesting that one reason the USFS has been seen as effective is the organization's sense of mission. Further, the service sees itself as a multi-purpose organization, with technical expertise providing a range of services to a variety of constituents. This includes timber production, forest maintenance, wildland fire management, and recreation (Clarke & McCool, 1985). To implement at the ecosystem level, the

USFS must incorporate some degree of ecosystem services. This relationship is addressed in the following section.

Ecosystem Management

The USFS adopted ecosystem-based management in 1994 as a method to address increasingly complex natural resource problems (Koontz & Bodine, 2008). Key elements of ecosystem-based management include the protection of ecosystem structure, function, and key processes, focus on a specific ecosystem and the range of activities affecting it, and the integration of ecological, social, economic, and institutional perspectives, recognizing their strong interdependencies (Tallis & Polasky, 2009).

In the USFS Rocky Mountain Region, these natural resource-related challenges are both natural, such as drought, climate change, and insect infestation, and human-related, including overuse and growth of the WUI adjacent to national forest property. Wildland fire fits into both categories. Management on the ecosystem scale also requires collaboration at the Federal, state, and local levels. This scale of management ties the ecosystem with the services it provides.

Ecosystem services. Ecosystems are defined as the complex of organisms that appear together in a given area and their associated abiotic environment, all interacting through the flow of energy to build biotic structure and material cycles (Ruhl, Kraft, & Lant, 2007). Building on this, ecosystem services is an anthropocentric concept and defined as the goods and services ecosystems produce that are important for human well-being (Tallis & Polasky, 2009). They can be considered the consequence of ecosystem interactions and functions (Ruhl et al., 2007). The Millennium Ecosystem Assessment [MEA] (2005) identified four categories of services. They are supporting, provisioning, regulating, and cultural.

Supporting services include nutrient cycling and soil formation. Food, fresh water, and timber are examples of provisioning services. The regulation of air quality and erosion, as well as water purification, are found in the third category of regulating services. Finally, cultural services include spiritual and religious values, aesthetic values, and recreation and tourism. These services, in turn, influence human well-being in areas such as health and basic material requirements (MEA, 2005). Daily et al. (2009) observe that the intent of understanding and valuing natural capital and ecosystem services is to make better decisions, resulting in better actions relating to the use of land, water, and other elements of natural capital. This contributes to understanding the costs and benefits of alternative actions being identified. A discussion of the relationship between ecosystem services and both wildland fire and forest management follow.

Wildfires on the landscape. Society places values on many non-market goods and services provided by the national forests that are affected positively and negatively by wildfires (Venn & Calkin, 2011). Fire is a natural component of the Rocky Mountain Region's ecosystems. Much of the landscape in the region evolved with fire and depends on this natural process to recycle nutrients, improve soil productivity, start plant succession processes, and contribute to overall watershed health (Dombeck et al., 2004). As previously noted, current Federal wildland fire policy states that fire, to the extent allowed by safety and protecting values at risk, should be allowed to function in its natural ecological role (WEFC, 2009). However, wildland fire managers have recently seen a significant increase in the number of incidents in the western region of the nation. Pyne (2010) suggests we are entering a period of megafires, which haven't been seen in decades. These fires have a high combustion intensity, are inherently complex to manage, and are dangerous to fire fighters. Many agencies believe they represent the future of wildfires. As a consequence, many ecosystems and human populations have become

increasingly vulnerable to large and severe wildfires (Cochrane et al., 2012). In addition, agencies have seen a significant increase in firefighting costs. The NWCG, located at the National Interagency Fire Center (NIFC), stated that the high costs of wildfire suppression, *particularly large and complex incidents* (italics added), are of considerable concern to Congress, the Office of Management and Budget, the Government Accountability Office, the public, and the agencies themselves (NWCG, 2009a, 2009b).

Research by Westerling, Hidalgo, Cayan, and Swetnam (2006) focused on 1166 large (>400 ha) forest wildfires between 1970 and 2003 on western, Federal land-management areas. Their research suggested that (a) the incidence of large wildfires significantly increased in the 1980s, (b) wildfire frequency was nearly four times the average of 1970 to 1986, and the total area burned was more than six and a half times its previous level, and (c) the length of the wildfire season increased by 78 days when comparing 1970 to 1986 with 1987 to 2003. Pyne (2010) concurs, suggesting this trend began in the late 1980's. Several of Colorado's largest fires have occurred during this same time frame (Rocky Mountain Research Station, 2011). When assessing the size and frequency of wildfires, the key item to consider for ecosystem services is fire severity. This is the ecosystem's response to fire and can be used to describe the effects of fire on the soil and water system, ecosystem flora and fauna, the atmosphere, and society (Neary et al., 2005).

Wildfires and ecosystems. The following summaries discuss the impact of wildfires and forest management on ecosystem services (Venn & Calkin, 2011; Neary et al., 2005).

Supporting services. In the short term, there is an increased availability of nutrients. Negatively, soil structure and nutrients can be lost, and the soil can become hydrophobic.

Provisioning services. Fire can affect water cycles by increasing water quantity. This includes annual and seasonal yields, base and peak flows, floods, and the timing of flows. Next to the physical destruction of the fire, floods are the most damaging aspect of a wildfire. As with the MPB infestation, increased water yield can be beneficial to water managers in the region.

Regulating services. The principal concern for changes in water quality are (a) the introduction of sediment, (b) potential for increasing nitrates, (c) the possible introduction of heavy metals from soils and geologic sources, and (d) the introduction of fire retardant chemicals into streams. Debris washed into waterways can potentially cause damage to structures (i.e., bridges) and impair the suitability of water for municipal and other users, potentially increasing costs. Air quality can also be degraded, causing health problems, reduced visibility, and smoke/soot damage to objects. Carbon sequestration will have positive and negative aspects. Wildfires will reduce fuel accumulation. Resulting wildfires may be less severe and could potentially release less carbon. Negatively, there could potentially be a large release of carbon during a wildfire.

Cultural services. There are potentially several positive and negative impacts. Positive aspects include (a) improved wildflower and wildlife viewing, (b) new or changed scenic vistas, (c) novelty of a burned forest, (d) improved habitat for certain species, with increased hunting successes, and (e) improved long-term fish habitat. Negatively, items of concern are (a) destruction of recreational facilities, (b) debris on trail systems and roadways, (c) loss of aesthetic value, and (d) short- to mid-term habitat deterioration for fish.

Forest management. Managers are using mechanical thinning and prescribed fires as treatment options for both the MPB infestation and wildfires. For the MPB infestation, mechanical thinning can remove stressed or unhealthy trees, prevent crowing and competition

among trees, and can effectively reduce the risk of an insect outbreak in a forest stand (Romme et al., 2006). The process can also reduce the risk to forest visitors along trails and in recreation sites (USFS, 2012d). In wildland fire management, mechanical thinning is used to reduce forest fuels (USFS, 2007).

Prescribed fires can replicate the benefits of wildfires on the landscape, assisting with the restoration of ecosystem health. Prescribed fires assist in maintaining biodiversity and reduce the risk to people and property. Properly managed, they also cause far less damage to ecological processes than uncontrolled, severe wildfires (McLoughlin, 2011). Prescribed fires are called the right fire, at the right place, at the right time. Based on the plan's controlling parameters, they provide many positive benefits to ecosystem services (USFS, 2012a; Neary et al., 2005).

Supporting services. Prescribed fires that consume major fuels, but protect the forest floor, humus layers, and soil humus are beneficial, allow nutrient cycling. There will be long-term benefits to this process.

Provisioning and regulating services. Increases in water quantity are generally lower than those associated with a wildfire. By limiting fire severity, avoiding burning on steep slopes, and limiting burning on potentially water-repellant soils, prescribed fires reduce the magnitude of the effects on water quality. Air quality can potentially be a concern and is monitored during a prescribed fire (Riebau & Fox, 2010). Carbon sequestration, as previously discussed, will have positive and negative aspects. Prescribed fires may be less severe and could potentially release less carbon. However, based on the plan, there could potentially be a large release of carbon during a prescribed fire.

Cultural services. The same positive and negative impacts of wildfires are generally applicable here. Destruction of recreational facilities is highly unlikely due to a prescribe fire.

In summary, ecosystem benefits would include (a) nutrient recycling, (b) promoting the growth of trees, wildflowers, and other plants, (c) providing forage for game, (d) removing invasive species, and (e) improving habitat (USFS, 2011b). In general, prescribed fires can be credited with increasing the relative supply of ecosystem services. The combination of adaptive management and policy developments, which incorporate ecosystem management, encompass what the USFS is trying to achieve by its management actions. The previous discussion about public perceptions and integrative complexity are linked to management actions by an agency taking into account how people think about an issue. These considerations should be incorporated into agency planning and outreach and collaboration efforts with the public and interested stakeholder groups.

The MPB infestation necessitates a long-term approach to dealing with not only forest health and management, but also the related aspects of wildland fire management. Policy makers and managers will have to develop long-term management plans for fuels treatments, protecting values at risk, recreation, and other areas. This suggests a continued level of cooperation and interaction between USFS supervisors and various agencies at the state and local levels, communities, working groups, and individuals. The literature suggests that several factors are critical during the public communication and collaboration step in policy implementation. These include trust of the USFS, sense of place considerations, stakeholder inclusion, and intent of the USFS communication effort (Absher and Bright, 2004; Lijeblad, Borrie, & Watson, 2009; Rivers, Wilson, & Arvai, 2008; Sturtevant & Lakes, 2008; Toman & Shindler, 2006; Zaksek & Arvai, 2004).

Summary

This review attempted to examine specific MPB-related literature, providing a foundation for the dissertation and its applied conceptual model. Most importantly, the review examined theoretical frameworks for this research. These theories, cognitive hierarchy and integrative complexity, were found to provide an appropriate structure for this research. The review further examined the MPB infestation as it relates to disturbance-driven landscapes, recreation, and economic considerations. The literature identified a strong understanding of the MPB and its role as a disturbance agent. Regarding wildfires, recent research suggests that the MPB may not have as strong a predictive influence on wildfires as previously believed. While the beetle does affect fuels, research suggests the relationship is complex and driven by other factors, such as climate. In regards to the beetle acting as a disturbance agent, the literature suggested that a community level of analysis was appropriate. When studying natural resources, communities form a primary backdrop for the study of human-environmental interactions. The recent, scholarly literature on recreation was limited. Several references, published by land-management agencies, dealt in general terms with safety in campgrounds, picnic areas, and trails. Other references dealt with aesthetic/scenic impacts and general recreation. Economic literature dealt with several subjects. These included the significant impact the MPB has on communities dependent on forest products. Research also addressed the opportunities and challenges for wood products and biomass as an alternative energy source.

Finally, the placement of the theoretical research into the concept model provides the "So what?" of the dissertation. Wildland fire management is complex. For fire managers, the Lower North Fork, High Park, and Waldo Canyon Fires represent the intricate connection of population growth in the WUI, agency and owner responsibility for mitigation, fire suppression activities,

resources, and policy implications (Burton, 2012; Cheng, 2012; Finley, 2012; Ingold & Mitchell, 2012; Keller, 2012; Kodas, 2012; Kodas & Hubbard, 2012; Eckhoff, 2012; State of Colorado, 2012). The direct application of the dissertation's theoretical results can potentially be of value to the USFS and other land-management agencies in the development of communication efforts and management plans. If agency managers know how the public views an issue, then information can be structured with the appropriate content, with the right level of complexity, for dissemination. Information can be tailored for the appropriate audience, focusing agency time and resources. The extent of the MPB infestation, and associated short- and long-term effects on wildland fire management, make this a worthy subject of continued study.

CHAPTER 3

Methods

Study Population and Sampling Procedures

The purpose of this study was to determine respondents' level of thought complexity toward prescribed fire and apply it to a conceptual framework in order to assist the USFS in developing prescribed fire-related policies, management actions, and communication strategies. A quantitative methodology was chosen in order to explore variable relationships through statistical analysis.

Households in counties contiguous to three study areas, located in northern Colorado and southern Wyoming, were the target of this social science research. The study areas were identified as "Front Range" (Colorado), "Northern" (Colorado and Wyoming), and "Central" (Colorado). The "Front Range" study area, located in Colorado, was comprised of Boulder, Clear Creek, Gilpin, Grand, Jefferson, and Larimer Counties. Jackson, Moffat, and Routt Counties in Colorado and Albany, Carbon, Converse, Laramie, and Natrona Counties in Wyoming comprised the "Northern" study area. The final study area, "Central," was comprised of Garfield, Eagle, Pitkin, Rio Blanco, and Summit Counties in Colorado. The sample was stratified by location in, and proximity to, each study area location. For each stratum, 1,500 names and addresses of households were obtained from a commercial source, providing a total random sample of 4,500 households. Of the total sample, a postal review identified 4,446 valid addresses, resulting in a random sample of 1,482 for each study location.

Assessment Protocol

A 12-page self-administered assessment, with a cover letter and map, was developed for the assessment. The concept table (Table 1) identifies the concepts, definitions, literature sources, and measurement methodology.

The research team worked with various collaborative partners to determine the study areas and assessment content. Partners included the CSFS, USFS, U.S. Geological Survey, and the University of Wyoming's Ruckelshaus Institute of Environment and Natural Resources. The social assessment was developed in several phases. The first, which began in December, 2010, was an elicitation study to identify specific assessment topics of interest determined by various collaborative partners. This included work meetings and, when necessary, coordination by phone if individuals were not available to meet. Information gathered in this phase was incorporated into the assessment design. Participative review of the assessment draft followed and was completed in August, 2011.

The researchers conducted a pilot test with 42 students enrolled in NRRT 372, Tourism Promotion, during the Fall, 2011, semester. The intent was to identify potential respondent problems, such as misreading or misunderstanding questions, being unable to answer questions, or an inability to maintain focus due to the assessment's length and completion time (Vaske, 2008). Participants took 16 to 30 minutes to complete the assessment. Several participants indicated that the inclusion of the study area map increased their response time. However, the research team did not feel this was a major detriment to participation. No changes or modifications were made.

The assessment was mailed to each sample household using multiple mailings. These included a pre-notification postcard, first assessment packet, and a thank you/reminder postcard

Table 1

Concepts pertinent to the research objectives

Concepts	Definitions	Literature Source(s)	Measurement
Beliefs about prescribed fires	Specific thoughts about prescribed fires; patterns of direction and intensity (value orientation)	Bright & Barro (2000); Carroll & Bright (2009, 2010); Tetlock (1989); integrative complexity as a moderator, Baron & Kenny (1986), Vaske (2008)	Open-ended arguments. Continuous variable; scale of 1 "Extremely weak" to 7 "Extremely strong"
Attitudes toward prescribed fires	Favorable or unfavorable evaluations of prescribed fires	Allen et al. (2009); Fishbein & Ajzen (1975); Eagly & Chaiken (1993); Vaske & Donnelly (1999)	Continuous variable; scale of 1 to 7 for Foolish/Wise, Ineffective/ Effective, and Harmful/ Beneficial
Beliefs about forests	Specific thoughts about forests; patterns of direction and intensity (value orientation)	Rosenberger & Smith (1997); Schindler et al. (1993); Vaske et al. (2001)	Continuous variable; scale of 1 "Strongly disagree" to 7 "Strongly agree"
Beliefs about fire and fire management	Specific thoughts about the role of fire in forests and agency fire management techniques; patterns of direction and intensity (value orientation)	Absher & Vaske (2005); Bright & Burtz (2006); Bright et al. (2003); Bright et al. (2007)	Continuous variable; scale of 1 "Strongly disagree" to 7 "Strongly agree."
Beliefs about trust	Specific thoughts about USFS and forest management; patterns of direction and intensity (value orientation)	Bright et al. (2003); Lijeblad, et al. (2009); Winter et al. (2004)	Continuous variable; scale of 1 "Strongly disagree" to 7 "Strongly agree."

sent to all 4,446 sample households. Based on responses to this first mailing group, a replacement assessment packet and a final thank you/reminder post card were sent to the remaining 3,750 sample households (Dillman, 2009; Vaske, 2008).

Sample

One hundred and thirty-eight assessments were either undeliverable or unusable. The total number of valid assessments returned from the two mailings was 783, an overall response rate of 18%. This number allowed the research team to state that with 95% confidence, the assessment responses represent the overall sample population, +/- 5% (Dillman, 2009). Due to time and funding, a non-response test was not conducted. This was not identified as a potential drawback for the dissertation, since the overall purpose of this study was to test a theoretical relationship between social psychology constructs (Burtz & Bright, 2007).

The first questionnaire mailing accounted for 611 (78%) of the total assessments, with the second mailing accounting for the remaining 172 (22%). The overall response rates were 21% for the Front Range (301 valid assessments), 16% for the Northern (234 valid assessments), and 17% for the Central (248 valid assessments) study areas. The Front Range location accounted for 38% of all returned assessments (Table 2).

Table 2

Valid Number of Assessments and Response Rates for Each Study Area

	Study Area		
	Front Range	Northern	Central
Sample	1482	1482	1482
Undeliverable or unusable assessment	41	43	54
Valid assessments (Total = 783)	301	234	248
Response rate (Overall = 18%)	21%	16%	17%
Percentage of overall responses	38%	30%	32%

Measurement of Key Variables

Several methods measured key variables. Questions that measured beliefs about forests, fire, fire management, and trust in the U.S. Forest Service used a 7-point Likert scale, where 1 = Strongly Disagree and 7 = Strongly Agree. Attitudes toward prescribed fire were measured in the same way. Based on adequate reliability, indices were created for the beliefs and attitudes (Absher, Vaske, & Bright, 2008; Bright & Carrol, 2009; Vaske, 2008).

Integrative complexity was measured using a scale recently developed by Bright and Carroll (2009). In their work, Bright and Carroll put the scale through a series of tests and revisions, with a final Pearson correlation of .81, $p<.01$, between traditional measurement methods and the scale. In this study, both components of integrative complexity, differentiation and integration, were measured. Two steps were involved in the scale development. First, in an open-ended format, respondents were asked to list any arguments supporting ("pro" arguments) prescribed burning. They were also asked to list any arguments against prescribed burning ("con" arguments). In the second step, respondents indicated the strength of each "pro" or "con" argument on a 7-point scale, where 1 = Extremely Weak and 7 = Extremely Strong.

To measure differentiation, the number of "pro" and "con" arguments were counted. The lower of the two was divided by the higher of the two. This resulted in a differentiation score between 0 and 1. A score of 0 indicated no differentiation and a score of 1 reflects the highest level of differentiation. The integration score was developed by finding the mean of the "pro" and "con" arguments. The lower mean was divided by the higher mean to obtain an integration score between 0 and 1. The lowest integration, represented by 0, occurs when there is a large difference in the perceived strength of "pro" and "con" arguments. A high integration score suggests that there is no difference in the strength of "pro" and "con" arguments. The overall

integrative complexity score was calculated by multiplying the differentiation and integration scores. This calculation yielded a value between 0 and 1.

Finally, the assessment asked a series of demographic questions to determine zip code of residence, length of time lived in or near current residence, length of time lived in Colorado and/or Wyoming, primary residence, age, gender, education, annual household income, and stakeholder group affiliation.

Reliability of Study Indices

Basic belief indices were developed by conducting a principal component analysis, using a varimax rotation, within each basic belief section (N = 783). The analysis identified eight clusters (Appendix A). Per Vaske (2008), all indices had adequate Cronbach's alphas: Trust (.80); Ecocentric Forest Beliefs (.85); Anthropocentric Forest Beliefs (.76); Fire Suppression (.84); Natural Fire (.74); Responsibility (.76); Freedom (.85); Recreation Limits (.75); Economic Use (.75); and Prescribed Fire (.86) (Table 3).

The principal component analysis was not used to develop two indices, Trust and Prescribed Fire. These indices had four or fewer belief statements in the original assessment. Three of the ten factors, Trust, Freedom, and Responsibility, confirm indices developed and validated by previous research (Absher et al., 2008; Carroll & Bright, 2009).

The four indices used to conduct the integrative complexity analysis were Trust, Freedom, Responsibility, and Fire Suppression. Trust, Freedom, and Responsibility were chosen because they have been used in previous research and provide a conceptual link to this analysis. Fire Suppression was used to measure respondents' acceptance of fire on the landscape. It was posited that this index would provide a means to examine respondents' attitudes towards prescribed fire.

Table 3

Reliability Analysis for Basic Belief Dimensions

Belief dimensions	Item Total Correlation	Alpha if Item Deleted	Cronbach Alpha
Trust			.80
I trust that forest managers know how to effectively conduct prescribed burning in national forests	.69	.73	
I trust that forest managers know how to respond to naturally caused forest fires in national forests	.68	.74	
I trust that forest managers know how to effectively manage smoke resulting from prescribed burns	.61	.76	
I trust that forest managers are doing everything they can to respond to the MPB outbreak	.56	.80	
Ecocentric			.85
Nature has as much right to exist as people	.83	.74	
Forests have as much right to exist as people	.86	.73	
Forests have value whether people are present or not	.49	.88	
Wildlife, plants, and people have equal rights to exist	.66	.84	
Anthropocentric			.76
Nature's primary value is to provide products	.63	.67	
Primary value of forest is to provide places to play	.53	.73	
Primary value of forest is to provide timber, grazing, and minerals	.64	.66	
Forests valuable only if they produce jobs and income	.49	.75	
Fire Suppression			.84
We should not allow forest fires to destroy wildlife and habitat	.73	.79	
Forest fire should be put out if endangering wildlife and habitat	.69	.80	
Losing wildlife and habitat is an acceptable result of allowing natural fires	.62	.82	
It is OK if some wildlife is lost to forest fires due to overall forest health	.58	.82	
Forest fires should be put out if they are going to destroy scenery	.61	.82	
Forest fire put out if decreases recreational opportunities in an area	.49	.84	

Table 3

Reliability Analysis for Basic Belief Dimensions (Cont'd)

Belief dimensions	Item Total Correlation	Alpha if Item Deleted	Cronbach Alpha
Natural Fire			.74
Forest fires started by lightning should be allowed to burn if controlled	.56	.66	
Forest fires started by lightning should be automatically put out	.63	.58	
Forest fires should be allowed to burn naturally even if scenery will be destroyed	.52	.72	
Responsibility			.76
When people build near national forests managers are primarily responsible to ensure private homes are protected	.64	.67	
People who build near national forests have the right to expect their home to be protected from fire by land managers	.56	.70	
Managers are primarily responsible for ensuring adjacent private property is not destroyed	.50	.72	
People who build homes near national forests are primarily responsible for protecting homes	.50	.72	
When people build homes near national forests, it is their fault if their homes are damaged by fire	.42	.75	
Freedom			.85
People should not be allowed to build homes near forests where they could be destroyed by fire	.76	.74	
There should be laws against building homes adjacent to a national forest where they could be damaged by fire	.72	.78	
People should be allowed to build homes near forests where fire could destroy them	.66	.84	
Recreation Limits			.75
People who recreate in national forests should accept that some places may not be accessible	.75	.44	
People that recreate in national forests should accept that some activities may be restricted or no longer possible	.71	.49	
Land managers know how to effectively manage tress that potentially pose a risk to people recreating	.32	.91	

Table 3

Reliability Analysis for Basic Belief Dimensions (Cont'd)

Belief dimensions	Item Total Correlation	Alpha if Item Deleted	Cronbach Alpha
Economic Use			.75
Land managers should facilitate the economic utilization of trees killed by the mountain pine beetle	.60	*	
Land managers should use trees killed by the mountain pine beetle for wood products and biomass	.60	*	

Creation of Attitude Variables

Three attitude variables were created to explore the relationship between integrative complexity and attitudes. The first of these was a 7-point attitude index, using the three prescribed fire attitude statements found in the social assessment. A dichotomous variable reflected whether respondents had positive or negative attitudes towards prescribed fire. Respondents were placed in a "positive" attitude group (a mean ≥ 4 on the attitude index), $n = 575$, or a "negative" attitude group (a mean < 4 on the attitude index) ($n = 50$). The third variable was a dichotomous variable reflecting respondent's moderate or extreme attitudes. Respondents with an attitude score ≥ 6 or ≤ 2 on the attitude index were placed in the "extreme" attitude group ($n = 233$). Those with an attitude score between 2 and 6 on the index were placed in the "moderate" attitude group ($n = 392$).

Analysis

This study analyzed original, empirical data found in an assessment of public perceptions of the MPB. The assessment, designed to gather data for the dissertation, also provided content for a descriptive report submitted to the USFS. A general summary of the pertinent results from the larger-scale study will be included in this section as the profile of respondents. This is followed by the results of the specific dissertation analysis (Research Objectives 1-5). The

research methodology for this study is based on related, previously-published works (Absher et al., 2008; Baron & Kenny, 1986; Bright et al., 2003; Carroll & Bright, 2009).

Analysis of Research Objectives

R1 was to examine whether there were different measurable levels of integrative complexity among participants when broken down by demographic status. Analysis of variance (ANOVA) and crosstabulations were used to analyze this research objective (Table 21).

R2 was to examine whether respondents with positive attitudes toward prescribed fire had a different level of integrative complexity than those with a negative attitude. Independent samples *t*-test compared the level of integrative complexity between these two groups (Table 22).

R3 was to examine whether respondents with extreme attitudes toward prescribed fire had a different level of integrative complexity than those with a moderate attitude. Independent samples *t*-test compared the level of integrative complexity between these two groups (Table 22).

R4 explored whether integrative complexity, measured using a 5-point Likert scale, was correlated to basic beliefs about wildland fire management. As identified by Barron and Kenny (1986), this is a key element in determining moderation. Pearson's correlations were used to examine the relationship between integrative complexity and the trust, freedom, responsibility, and fire suppression belief indices (Table 23).

R5 explored the moderating effects of integrative complexity on the relationship between basic belief indices (dimensions) and prescribed fire attitudes (Baron & Kenny, 1986; Tarrant, Bright & Cordell, 1997). Moderation analysis was conducted separately for each belief dimension (Table 24). Three regressions were conducted in each analysis. First, the prescribed fire attitude index (DV) was regressed on the belief dimension (IV). Next, attitude was regressed on the belief dimension and integrative complexity 5-point Likert scale. Finally, attitude was

regressed on the belief dimension, integrative complexity scale, and a multiplicative interaction of these two independent variables.

Baron and Kenny (1986) observe that if, in the final regression, the betas for the main effects of the independent variables change and the interaction is significant, moderation occurred. Carroll and Bright (2009) suggest that significant moderation means the strength of the relationship between basic beliefs about wildland fire management and attitude toward prescribed fire is different for respondents with high integrative complexity compared to those with low integrative complexity.

Additional analysis was conducted on the analyses which suggested moderation (Table 25). Two integrative complexity groups, *high* and *low,* were created. For each group, attitude was separately regressed on the basic belief dimensions. The R^2 and beta coefficients were compared to provide descriptive information about the nature of the moderation (Carroll & Bright, 2009).

Additional Statistical Analysis

The following statistics were used for the analysis of additional subjects. Descriptive statistics (frequency) were used to obtain the valid number of assessments (Table 2).

Profile of respondents. Descriptive statistics (mean and standard deviation), and an analysis of variance (ANOVA), with post-hoc tests, were used for Table 4. A crosstabulation analysis was used for Tables 5, 7, and 8. A frequency analysis (percentages) was used for Tables 6 and 9.

Study location analysis. The dominant beliefs about fuels management (prescribed fire), forests, fire, fire management, and trust were examined. The USFS, as a land management agency, was the object of the trust statements. This objective explored if there were significant

differences between the three study locations. A crosstabulation was used for Tables 10, 11, and 12. Descriptive statistics (mean and standard deviation), analysis of variance (ANOVA), with post-hoc tests, and crosstabulations were used for Tables 13-20.

Reliability of study indices. A principal component analysis was conducted to uncover a cluster of related variables (e.g., a factor) in a larger set of variables (Vaske, 2008). A reliability analysis was then conducted on these clusters to determine the internal consistency of the items (Table 3 and Appendix A) (Vaske, 2008).

CHAPTER 4

Results

The purpose of the investigation was to determine respondents' level of thought complexity toward prescribed fire and apply it to a conceptual framework in order to assist agencies in developing prescribed fire-related policies, management actions, and communication strategies. This chapter presents a descriptive profile of respondents and the results of the analyses described in the previous chapter.

Results are presented in two sections. The first contains a demographic analysis. Tables and/or graphs are used to present the data, accompanied by a discussion of the major findings. Since the total sample (N = 783) consists of three distinct study areas, subsample comparisons are presented to highlight key differences between the sample groups. Sample sizes vary slightly per assessment item due to missing data. The second section consists of the results for research objectives 1 through 5. These objectives specifically deal with the analysis of integrative complexity. Tables are used to present the data in this section.

Demographic Analysis

On average, respondents lived in or near their current residences for 19 years. The mean number of years for the Front Range, Northern, and Central study areas were 17 (SD = 12.91), 24 (SD = 18.71), and 18 (SD = 14.55) respectively. The number of years lived in Colorado or Wyoming were 32 (SD = 17.84), 40 (SD = 22.29), and 31 (SD = 19.14) for the Front Range, Northern, and Central locations, respectively (Table 4). There was a statistically significant difference between the Northern respondents and the other two study areas in both of the residential categories. The mean respondent age was 56 years (SD = 14.71). There was no practical age difference between the three respondent sub-groups (Tables 4 and 5).

Table 4

Table for Length of Residence and Age

	Study Area							
	Front Range (n=288)[1]		Northern (n=211)[1]		Central (n=241)[1]		Total (n=738)[1]	
	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation
Number of years lived in or near your current residence	17.15[a]	12.91	23.85[b]	18.71	17.90[a]	14.55	**19.29*** **	15.52
Number of years lived in Colorado or Wyoming	32.37[a]	17.84	39.84[b]	22.29	31.20[a]	19.14	**34.13*** **	20.04
What is your age?	55.32	13.53	56.41	16.81	55.02	14.12	55.53	14.71

*** Significant at the .001 level.

[a,b]Superscript letters reflect statistically significant differences between means.

[1] Sample size varies slightly due to missing data; exact counts per item not given due to space limitations.

Table 5

Table for Respondent Age Categories

Age Categories	Study Area		
	Front Range (n=286)[1]	Northern (n=211)[1]	Central (n=241)[1]
17-19	---	0.9%	0.4%
20-29	3.8%	6.2%	5.0%
30-39	9.8%	11.4%	8.7%
40-49	16.8%	12.8%	16.6%
50-59	29.7%	21.8%	33.6%
60-69	28.0%	23.7%	20.3%
70-79	7.7%	15.2%	11.2%
80-89	4.2%	6.6%	4.1%
90-92	---	1.4%	---
	100.0%	100.0%	100.0%

[1] Sample size varies slightly due to missing data; exact counts per item not given due to space limitations.

Overall, 63.2% of the respondents were male (Table 6). Regarding respondent education, educational levels ranged from less than a high school degree to one or more graduate degrees (Table 7). The two highest response categories for Front Range respondents were “One or more

Table 6

Table for Respondent Gender

	Study Area			
	Front Range (n=287)[1]	Northern (n=214)[1]	Central (n=240)[1]	Total (n=741)[1]
Male	58.5%	70.1%	62.5%	63.2%
Female	41.5%	29.9%	37.5%	36.8%

[1] Sample size varies slightly due to missing data; exact counts per item not given due to space limitations.

Table 7

Table for Respondent Education Level

Education Level	Study Area		
	Front Range (n=287)[1]	Northern (n=210)[1]	Central (n=240)[1]
Less than high school	1.0%	1.9%	0.4%
High school diploma or GED	12.9%	24.3%	14.2%
Technical or vocational or associate	12.9%	16.7%	12.5%
Four year college degree	27.2%	21.0%	39.6%
Some graduate work	13.6%	10.5%	12.9%
One or more graduate degrees	32.4%	25.7%	20.4%
	100.0%	100.0%	100.0%

[1] Sample size varies slightly due to missing data; exact counts per item not given due to space limitations.

graduate degrees" (32.4%) and "Four year college degree" (27.2%). For Northern respondents, they were "One or more graduate degrees" (25.7%) and "High school diploma or GED" (24.3%). The two highest response categories for Central respondents were "Four year college degree" (39.6%) and "One or more graduate degrees" (20.4%).

Income was not skewed toward higher levels. The income level with the highest response percentage, in all three study areas, was $50,000 to $74,999 a year (Table 8). Responses did not represent a sample population that was predominantly retired (Table 9). Sixty-nine percent of respondents were still employed.

Table 8

Table for Respondent Approximate Annual Household Income Before Taxes

Annual Income	Study Area		
	Front Range (n=267)[1]	Northern (n=192)[1]	Central (n=220)[1]
Less than $10,000	2.6%	3.6%	3.2%
$10,000 to $24,999	9.4%	7.8%	5.9%
$25,000 to $49,999	17.2%	21.9%	17.3%
$50,000 to $74,999	19.9%	26.0%	18.2%
$75,000 to $99,999	15.4%	15.6%	16.8%
$100,000 to $124,999	16.5%	12.5%	15.9%
$125,000 to $149,999	7.8%	5.3%	8.2%
$150,000 or more	11.2%	7.3%	14.5%
	100.0%	100.0%	100.0%

[1] Sample size varies slightly due to missing data; exact counts per item not given due to space limitations.

Table 9

Table for Respondent Retirement Status

Retired?	Study Area			Total (n=732)[1]
	Front Range (n=285)[1]	Northern (n=211)[1]	Central (n=236)[1]	
Yes	29.1%	36.0%	28.0%	30.7%
No	70.9%	64.0%	72.0%	69.3%

[1] Sample size varies slightly due to missing data; exact counts per item not given due to space limitations.

Beliefs about Fuels Management (Prescribed Fire)

This section measured respondent's positive or negative attitudes with three questions. The first asked whether this practice was a wise or foolish strategy; 38.8% of all respondents replied that it was "Moderately wise" (Table 10). This was the same for all three response groups. Forty-two percent of Front Range respondents replied the same, as did 37.4% of Northern and 36.4% of Central respondents. Northern respondents had a higher neutral response rate, 17.5%, than did Front Range, 9.6%, or Central, 8.9%.

Table 10

Results for the Question whether Prescribed Burning is a Wise or Foolish Strategy

	Study Area			
	Front Range	Northern	Central	Total
Extremely wise	78	40	70	188
	27.9%	19.0%	29.7%	25.9%
Moderately wise	117	79	86	282
	41.8%	37.4%	36.4%	38.8%
Slightly wise	33	21	35	89
	11.8%	10.0%	14.8%	12.2%
Neutral	27	37	21	85
	9.6%	17.5%	8.9%	11.7%
Slightly foolish	18	15	8	41
	6.4%	7.1%	3.4%	5.6%
Moderately foolish	2	11	9	22
	.7%	5.2%	3.8%	3%
Extremely foolish	5	8	7	20
	1.8%	3.8%	3.0%	2.8%
	280	211	236	727
	100%	100%	100%	100%

The second question asked whether the practice was effective or ineffective at reducing the dangers of wildfire. Results were similar. In each response group, “Moderately effective” was once again the highest percentage, with 44.4% overall (Table 11). The Front Range had the highest percentage, 48.6%, Central following with 43.2% and Northern with 40.2%.

Table 11

Results for the Question whether Prescribed Burning is Effective or Ineffective at Reducing the Dangers of Wildfire

	Study Area			
	Front Range	Northern	Central	Total
Extremely effective	63 22.7%	50 24.5%	60 26.2%	173 24.3%
Moderately effective	135 48.6%	82 40.2%	99 43.2%	316 44.4%
Slightly effective	39 14.0%	32 15.7%	39 17%	110 15.5%
Neutral	23 8.3%	23 11.3%	22 9.6%	68 9.6%
Slightly ineffective	9 3.2%	6 2.9%	4 1.7%	19 2.7%
Moderately ineffective	7 2.5%	7 3.4%	1 .4%	15 2.1%
Extremely ineffective	2 .7%	4 2.0%	4 1.7%	10 1.4%
	278	204	229	711
	100%	100%	100%	100%

The final question asked whether the practice was beneficial or harmful to the health of the forest (Table 12). Responses for the Northern and Central study areas reflected an "Extremely beneficial" attitude. Nearly 44% of Central and 33.7% of Northern respondents answered in this way. The largest response for the Front Range was "moderately beneficial," with 39.1%.

Beliefs about Forests

Results suggest respondents view the forests as being important (Tables 13 and 14). Respondents collectively disagreed with the forests being valued primarily as a source of products, recreation, jobs, or income. This section, and the following belief sections,

Table 12

Results for the Question whether Prescribed Burning is Beneficial or Harmful to the Health of the Forest

	Study Area			
	Front Range	Northern	Central	Total
Extremely beneficial	99 35.5%	70 33.7%	103 43.8%	272 37.7%
Moderately beneficial	109 39.1%	68 32.7%	80 34.0%	257 35.6%
Slightly beneficial	31 11.1%	24 11.5%	25 10.6%	80 11.1%
Neutral	26 9.3%	26 12.5%	21 8.9%	73 10.1%
Slightly harmful	9 3.2%	8 3.8%	4 1.7%	21 2.9%
Moderately harmful	4 1.4%	7 3.4%	1 .4%	12 1.7%
Extremely harmful	1 .4%	5 2.4%	1 .4%	7 1%
	279	208	235	722
	100%	100%	100%	100%

Table 13

Table of Means for Beliefs about Forests

	Study Area							
	Front Range (n=291)[1]		Northern (n=217)[1]		Central (n=244)[1]		Total (n=751)[1]	
	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
Nature has as much right to exist as people	5.96	1.61	5.94	1.58	6.03	1.59	5.98	1.59
Forests have as much right to exist as people	5.90	1.60	5.95	1.55	5.96	1.59	5.94	1.58
Forests have value whether people are there or not	6.68	.83	6.52	1.10	6.66	.95	6.63	.95
Wildlife, plants, and people should have equal rights to live and develop	5.22	1.97	5.27	1.86	5.27	1.95	5.25	1.93
Value of forests exists only in the human mind; without people, forests have no value	1.55[a]	1.34	1.89[b]	1.49	1.57[a,b]	1.39	**1.66***	1.41
Nature's primary value is to provide products useful to people	2.36[a]	1.79	3.23[b]	2.02	2.50[a]	1.79	**2.66*****	1.89
Primary value of forest is to provide places to play and recreate	2.55[a]	1.67	3.02[b]	1.79	2.78[a]	1.77	**2.76***	1.75
Primary value of forest is to provide timber, grazing, and minerals for people who depend on them for their way of life	2.83[a]	1.87	3.38[b]	1.89	2.96[a,b]	1.80	**3.03***	1.87
Forests are valuable only if they produce jobs and income for people	1.54[a]	1.54	2.03[b]	1.48	1.63[a,b]	1.08	**1.71*****	1.21

Items measured on 7-point Likert agreement scales (1=strongly disagree, 2=disagree, 3=slightly disagree, 4=neutral, 5=slightly agree, 6=agree, 7=strongly agree).
[*]Significant at the .05 level. [***] Significant at the .001 level.
[a,b]Superscript letters reflect statistically significant differences between means. [1] Sample size varies slightly per assessment item due to missing data; exact counts per item not given due to space limitations.

Table 14

Percentage of Agreement for Beliefs about Forests

	Total (n=751)[1]			Front Range (n=291)[1]			Northern (n=217)[1]			Central (n=244)[1]		
	Disagree	Neutral	Agree	Disagree	Neutral	Agree	Disagree	Neutral	Agree	Disagree	Neutral	Agree
Nature has as much right to exist as people	10%	7%	83%	11%	7%	82%	9%	7%	84%	10%	6%	84%
Forests have as much right to exist as people	9%	7%	84%	10%	8%	82%	9%	7%	84%	10%	7%	83%
Forests have value whether people are there or not	2%	1%	97%	1%	2%	97%	4%	1%	95%	2%	1%	97%
Wildlife, plants, and people should have equal rights to live and develop	20%	10%	70%	22%	8%	70%	18%	13%	69%	19%	10%	71%
Value of forests exists only in the human mind; without people, forests have no value	90%	3%	7%	91%	2%	7%	86%	7%	7%	93%	1%	6%
Nature's primary value is to provide products useful to people	71%	9%	20%	78%	6%	16%	57%	14%	29%	74%	8%	18%
Primary value of forest is to provide places to play and recreate	68%	13%	19%	72%	11%	17%	62%	16%	22%	68%	11%	21%
Primary value of forest is to provide timber, grazing, and minerals for people who depend on them for their way of life	63%	12%	25%	67%	10%	23%	55%	15%	30%	65%	12%	23%
Forests are valuable only if they produce jobs and income for people	91%	5%	4%	94%	3%	3%	85%	9%	6%	94%	3%	3%

Items recoded from 7-point Likert agreement scales to 3 point scales.

[1] Sample size varies slightly due to missing data; exact counts per item not given due to space limitations.

used a 7-point Likert scale for measurement, where 1 = "Strongly Disagree" and 7 = "Strongly Agree."

Regarding beliefs about forests, 97% of all respondents believe that forests have value, whether people are there or not (M = 6.63, SD = .95). In addition, 84% believe that forests have the right to exist (*M* = 5.94, *SD* = 1.58). Twenty-five percent of respondents agreed that the primary value of the forest is to provide timber, grazing, and minerals (*M* = 3.03, *SD* = 1.87). Thirty percent of Northern respondents agreed with this statement. Finally, 20% agreed that nature's primary value is to provide products (*M* = 2.66, *SD* = 1.89).

Beliefs about Fire

Results suggest respondents understand the natural role of fire on the landscape (Tables 15 and 16). For example, 59% of respondents agreed that wildfires should be allowed to burn, even if scenery will be destroyed (*M* = 4.59, *SD* = 1.80). In addition, 77% agreed that it is acceptable for some wildlife to be lost to wildfires due to overall forest health (*M* = 5.17, *SD* = 1.63). Results also suggest support for allowing lightning-caused wildfires to burn, less for human-caused wildfires. Seventy-six percent of respondents disagreed when asked if wildfires started by lightning should be automatically put out (*M* = 2.66, *SD* = 1.65). Conversely, 58% of respondents agreed that wildfires started by people should be automatically suppressed (*M* = 4.75, *SD* = 1.86). It should be noted that, overall, most levels of agreement were in the "Slightly agree" range. Significant differences, between the study areas, were found for variables dealing with suppressing fires that endanger wildlife and habitat, as well as decreasing recreational opportunities in an area.

Table 15

Table of Means for Beliefs about Fire

	Study Area							
	Front Range (n=291)[1]		Northern (n=215)[1]		Central (n=242)[1]		Total (n=749)[1]	
	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
If a forest fire is endangering wildlife and its habitat, the fire should automatically be put out.	3.57[a,b]	1.97	3.81[b]	1.97	3.24[a]	1.88	**3.53**[**]	1.95
OK that some wildlife is lost due to forest fire since benefits the overall health of the forest	5.10	1.69	5.08	1.56	5.35	1.61	5.17	1.63
Forest fires should be put out if they are going to decrease recreational opportunities in an area	2.92[a]	1.64	3.46[b]	1.75	3.24[a,b]	1.74	**3.18**[**]	1.72
We should not allow wildlife and its habitat to be destroyed by forest fire	3.32	1.99	3.39	1.93	3.13	1.88	3.28	1.94
Forest fires should be allowed to burn naturally even if scenery will be destroyed	4.68	1.78	4.35	1.78	4.69	1.82	4.59	1.80
Forest fires started by people should be automatically put out	4.77	1.87	4.82	1.92	4.67	1.80	4.75	1.86
Losing wildlife and its habitat is an acceptable result of allowing natural fires to burn in forests	4.90	1.79	4.64	1.76	5.03	1.78	4.87	1.78
Forest fires should be put out if they are going to destroy scenery	2.87	1.71	3.07	1.69	2.90	1.66	2.94	1.69
Forest fires started by lightning should be allowed to burn as long as they can be controlled	4.99	1.68	4.99	1.73	5.29	1.72	5.09	1.71
Forest fires started by lightning should be automatically put out	2.71	1.69	2.80	1.70	2.47	1.54	2.66	1.65

Table 15

Table of Means for Beliefs about Fire (Cont'd)

Forest fires started by people should be allowed to burn as long as they can be controlled	3.73	1.85	3.52	1.95	3.78	1.94	3.69	1.91

Items measured on 7-point Likert agreement scales (1=strongly disagree, 2=disagree, 3=slightly disagree, 4=neutral, 5=slightly agree, 6=agree, 7=strongly agree). ** Significant at the .01 level. [a,b]Superscript letters reflect statistically significant differences between means. [1] Sample size varies slightly due to missing data; exact counts per item not given due to space limitations.

Table 16

Percentage of Agreement for Beliefs about Fire

	Total (n=749)[1]			Front Range (n=291)[1]			Northern (n=215)[1]			Central (n=242)[1]		
	Disagree	Neutral	Agree	Disagree	Neutral	Agree	Disagree	Neutral	Agree	Disagree	Neutral	Agree
If a forest fire is endangering wildlife and its habitat, the fire should automatically be put out.	58%	9%	33%	57%	9%	34%	50%	13%	37%	65%	7%	27%
OK that some wildlife is lost due to forest fire since benefits the overall health of the forest	16%	7%	77%	18%	5%	76%	15%	12%	73%	13%	6%	81%
Forest fires should be put out if they are going to decrease recreational opportunities in an area	61%	13%	25%	69%	12%	19%	55%	15%	30%	59%	13%	28%
We should not allow wildlife and its habitat to be destroyed by forest fire	62%	10%	28%	62%	9%	30%	58%	13%	30%	67%	9%	24%
Forest fires should be allowed to burn naturally even if scenery will be destroyed	29%	12%	59%	26%	14%	60%	33%	15%	52%	29%	8%	62%
Forest fires started by people should be automatically put out	28%	14%	58%	28%	12%	60%	29%	13%	58%	28%	17%	56%
Losing wildlife and its habitat is an acceptable result of allowing natural fires to burn in forests	22%	8%	70%	21%	7%	72%	27%	10%	62%	19%	6%	74%
Forest fires should be put out if they are going to destroy scenery	69%	12%	19%	73%	9%	18%	64%	15%	21%	69%	12%	19%

Table 16

Percentage of Agreement for Beliefs about Fire (Cont'd)

Forest fires started by lightning should be allowed to burn as long as they can be controlled	18%	10%	72%	20%	9%	71%	19%	13%	68%	15%	8%	77%
Forest fires started by lightning should be automatically put out	76%	10%	14%	77%	9%	15%	70%	15%	15%	81%	7%	12%
Forest fires started by people should be allowed to burn as long as they can be controlled	49%	12%	39%	48%	11%	41%	51%	15%	33%	49%	12%	40%

Items recoded from 7-point Likert agreement scales to 3 point scales.
[1] Sample size varies slightly due to missing data; exact counts per item not given due to space limitations.

Beliefs about Fire Management

Results suggest respondents support management of forest conditions to decrease the effects of a wildfire (Tables 17 and 18). Seventy-seven percent of respondents agreed with managing forest conditions to decrease the effects of a wildfire (M = 5.33, SD = 1.51). Regarding individual responsibility, 86% of the overall respondents believe individuals are primarily responsible for protecting homes near national forests (M = 5.85, SD = 1.51). Seventy-three percent of respondents disagreed with the statement that people who build near national forests have a right to expect their home to be protected from fire by land managers (M = 2.64, SD = 1.72). However, respondents don't agree with restricting home building near national forest land. Seventy-three percent of the overall respondents disagreed with the statement that people should not be allowed to build homes on private property near forests where they could be destroyed by fire (M = 2.63, SD = 1.77). There were significant differences among the three study areas within several variables.

Beliefs about trust

Results suggest that 82% of respondents agree that forest managers know how to effectively conduct prescribed fires (M = 5.48, SD = 1.46), while 87% agree that forest managers know how to respond to naturally-caused wildfires (M = 5.71, SD = 1.31) (Tables 19 and 20). However, a lower number, 61%, agree that forest mangers know how to effectively manage smoke resulting from prescribed fires (M = 4.73, SD = 1.73). Only 59% of respondents agreed that forest managers are doing everything that can be done to respond to the mountain pine beetle outbreak (M = 4.67, SD = 1.94). Results suggest significant differences between the three study areas for each variable.

Table 17

Table of Means for Beliefs about Fire Management

	Study Area							
	Front Range (n=291)[1]		Northern (n=217)[1]		Central (n=244)[1]		Total (n=751)[1]	
	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
Land managers should manage forest conditions to decrease the effects of a forest fire	5.40	1.47	5.34	1.56	5.24	1.53	5.33	1.51
People should be allowed to build homes on private property near forests where homes could be destroyed by fire	5.10	1.80	5.05	1.90	5.26	1.78	5.14	1.82
If a fire breaks out in a national forest, land managers should be primarily responsible for ensuring adjacent private property is not destroyed	3.49[a]	1.85	3.55[a]	1.93	4.06[b]	1.96	**3.69***	1.93
People who build homes on private land near national forests have the primary responsibility for protecting their own home from forest fire	5.86	1.46	5.88	1.61	5.82	1.48	5.85	1.51
When people build homes near national forests, land managers should have the primary responsibility to make sure private homes are protected from forest fire	2.91	1.73	3.02	1.93	3.18	1.86	3.03	1.83
When people build homes near national forests, they have the right to expect their home to be protected from fire by land managers	2.62	1.71	2.60	1.74	2.71	1.72	2.64	1.72
Land managers should not use measures like prescribed burning to decrease the chance of wildfire in a forest	2.40[a]	1.64	2.75[b]	1.67	2.42[a]	1.67	**2.50***	1.66

Table 17

Table of Means for Beliefs about Fire Management (Cont'd)

People should not be allowed to build homes on private property near forests where they could be destroyed by fire	2.73	1.82	2.76	1.87	2.42	1.61	2.63	1.77
We should leave forests alone instead of trying to manipulate their conditions	3.48	1.74	3.38	1.90	3.48	1.79	3.45	1.80
There should be laws against building homes adjacent to a national forest where they could be damaged by forest fire	2.60[a]	1.78	2.56[a, b]	1.82	2.25[b]	1.61	**2.48***	1.74
When people build homes near national forests, it is their fault if their homes are damaged by fire	4.74	1.90	5.02	1.92	4.76	1.90	4.83	1.91

Items measured on 7-point Likert agreement scales (1=strongly disagree, 2=disagree, 3=slightly disagree, 4=neutral, 5=slightly agree, 6=agree, 7=strongly agree).

[*] Significant at the .05 level.

[a,b]Superscript letters reflect statistically significant differences between means.

[1] Sample size varies slightly due to missing data; exact counts per item not given due to space limitations.

Table 18

Percentage of Agreement for Beliefs about Fire Management

	Total (n=751)[1]			Front Range (n=291)[1]			Northern (n=217)[1]			Central (n=244)[1]		
	Disagree	Neutral	Agree	Disagree	Neutral	Agree	Disagree	Neutral	Agree	Disagree	Neutral	Agree
Land managers should manage forest conditions to decrease the effects of a forest fire	12%	10%	77%	11%	10%	79%	12%	10%	78%	14%	12%	74%
People should be allowed to build homes on private property near forests where homes could be destroyed by fire	20%	9%	71%	20%	7%	73%	22%	11%	67%	17%	11%	72%
If a fire breaks out in a national forest, land managers should be primarily responsible for ensuring adjacent private property is not destroyed	49%	12%	39%	54%	10%	36%	53%	14%	33%	40%	12%	48%
People who build homes on private land near national forests have the primary responsibility for protecting their own home from forest fire	10%	4%	86%	10%	3%	87%	11%	3%	86%	10%	5%	85%
When people build homes near national forests, land managers should have the primary responsibility to make sure private homes are protected from forest fire	65%	10%	26%	68%	9%	23%	65%	12%	24%	60%	9%	31%

Table 18

Percentage of Agreement for Beliefs about Fire Management (Cont'd)

When people build homes near national forests, they have the right to expect their home to be protected from fire by land managers	73%	8%	19%	74%	8%	19%	74%	8%	18%	72%	7%	20%
Land managers should not use measures like prescribed burning to decrease the chance of wildfire in a forest	78%	9%	13%	81%	4%	14%	73%	12%	14%	78%	12%	11%
People should not be allowed to build homes on private property near forests where they could be destroyed by fire	73%	10%	17%	72%	10%	18%	70%	11%	19%	77%	11%	12%
We should leave forests alone instead of trying to manipulate their conditions	56%	13%	31%	54%	16%	30%	58%	12%	30%	57%	11%	33%
There should be laws against building homes adjacent to a national forest where they could be damaged by forest fire	75%	10%	16%	73%	10%	18%	72%	11%	17%	79%	9%	12%
When people build homes near national forests, it is their fault if their homes are damaged by fire	27%	10%	63%	27%	12%	61%	24%	7%	69%	28%	11%	61%

Items recoded from 7-point Likert agreement scales to 3 point scales.

[1] Sample size varies slightly due to missing data; exact counts per item not given due to space limitations.

Table 19

Table of Means for Beliefs about Trust

	Study Area							
	Front Range (n=291)[1]		Northern (n=217)[1]		Central (n=245)[1]		Total (n=753)[1]	
	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
I trust that forest managers know how to effectively conduct prescribed burning in national forests	5.60[a]	1.29	5.27[b]	1.63	5.51[a,b]	1.48	**5.48***	1.46
I trust that forest managers know how to respond to naturally caused forest fires in national forests	5.92[a]	1.06	5.56[b]	1.46	5.59[b]	1.42	**5.71***	1.31
I trust that forest managers know how to effectively manage smoke resulting from prescribed burns	4.92[a]	1.53	4.41[b]	1.84	4.80[a,b]	1.76	**4.73***	1.73
I trust that forest managers are doing everything they can to respond to the MPB outbreak in national forests	5.03[a]	1.75	4.41[b]	2.07	4.48[b]	1.97	**4.67*****	1.94

Items measured on 7-point Likert agreement scales (1=strongly disagree, 2=disagree, 3=slightly disagree, 4=neutral, 5=slightly agree, 6=agree, 7=strongly agree).

* Significant at the .05 level. *** Significant at the .001 level.

[a,b]Superscript letters reflect statistically significant differences between means.

[1] Sample size varies slightly per assessment item due to missing data; exact counts per item not given due to space limitations.

Table 20

Percentage of Agreement for Beliefs about Trust

	Total (n=753)[1]			Front Range (n=291)[1]			Northern (n=217)[1]			Central (n=245)[1]		
	Disagree	Neutral	Agree	Disagree	Neutral	Agree	Disagree	Neutral	Agree	Disagree	Neutral	Agree
I trust that forest managers know how to effectively conduct prescribed burning in national forests	11%	7%	82%	8%	6%	86%	17%	6%	77%	11%	8%	81%
I trust that forest managers know how to respond to naturally caused forest fires in national forests	7%	6%	87%	3%	5%	92%	10%	6%	84%	9%	7%	84%
I trust that forest managers know how to effectively manage smoke resulting from prescribed burns	22%	17%	61%	17%	16%	67%	29%	20%	51%	22%	15%	63%
I trust that forest managers are doing everything they can to respond to the MPB outbreak in national forests	28%	13%	59%	20%	11%	69%	33%	11%	56%	32%	16%	52%

Items recoded from 7-point Likert agreement scales to 3 point scales.

[1] Sample size varies slightly due to missing data; exact counts per item not given due to space limitations.

Integrative Complexity

Demographic Influence on Integrative Complexity

Data was analyzed for this objective using the following research objective:

R1: Determine whether demographics influence respondent levels of integrative complexity.

The creation of two new integrative complexity variables was required to examine this component of the first research objective and following research objectives. The first of these was a dichotomous, integrative complexity *high* or *low* score (N = 658). The high or low score was calculated using each respondent's final integrative complexity score (M = .51, SD = .50). Scores of .50 or above were designated *high* (n = 338, 51.4%), while those below .49 were designated *low* (n = 320, 48.6%).

The second variable was a continuous, 5-point Likert scale measuring integrative complexity, again using each respondent's final score. Because the final score ranged from 0 to 1, a five-point Likert scale was developed (N = 658). In this scale, 1 = *Very Low* (0 to .19, n = 133, 20.2%), 2 = *Low* (.20 to .39, n = 129, 19.6%), 3 = *Mid Range* (.40 to .59, n = 135, 20.5%), 4 = *High* (.60 to .79, n = 126, 19.2%), and 5 = *Very High* (.80 to 1, n = 135, 20.5%). The overall mean and standard deviations were 3.00 and 1.42, respectively.

Using the new variables, this examination explored whether there was a different, measurable level of integrative complexity, when broken down by a respondent's location and demographic status. An analysis was conducted using study location, gender, education, and income. Using the study location, there were no significant differences in the level of integrative complexity. The means for the Front Range, Northern, and Central study areas were M = 3.02, M = 3.02, and M = 2.96, respectively, while the standard deviations were SD = 1.38, SD = 1.49, and

SD = 1.41. There was also no significant difference when analyzing study areas by integrative complexity "high" and "low" scores.

The overall means and standard deviations for male and female integrative complexity scores were *M* = 2.92, *SD* = 1.43, and *M* = 3.15, *SD* = 1.38, respectively. The difference was marginally significant, $t(644) = -1.98$, $p = .048$, $d = .16$. There were no significant differences when comparing gender by study areas. However, results suggest that there is also a marginally significant difference between integrative complexity "high" and "low" scores, when analyzed by gender, $\chi^2(1, N = 646) = 4.10$, $p = .043$, (Table 21). Finally, results suggest there were no significant differences when comparing integrative complexity, including "high" and "low" scores, with income and education.

It should be noted that all effect sizes in **R1** were minimal to typical.

Table 21

Comparison of Integrative Complexity High and Low Scores by Gender

	Gender					
IC score	Male	Female	Total	χ^2 value	*p*-value	Cramer's *V*
Low	51.6%, 215	43.2%, 99	48.6%, 314	4.10	.043	.08
High	48.4%, 202	56.8%, 130	51.4%, 332			
Total	100%, 417	100%, 229	100%, 646[a]			

[a] *N* = 646

Integrative Complexity and Attitude Direction

The purpose of this research objective was to examine the relationship between attitude direction and levels of integrative complexity. The proposed research objective was to:

R2: Determine if respondents with positive attitude direction toward prescribed fire hold different levels of integrative complexity than respondents with negative attitudes.

While respondents with a positive attitude had a higher mean level of integrative complexity (M = .49, SD = .31) than those with a negative attitude (M = .44, SD = .35), there was no significant difference between these scores (Table 22).

Table 22

Comparison of Integrative Complexity (IC) Between Attitude Direction and Extremity Groups: Independent Samples T-tests

	n	Mean IC	SD	*t*-value	*p*-value
Attitude Direction					
Positive Attitude	575	.49	.31	1.19	.234
Negative Attitude	50	.44	.35		
Attitude Extremity					
Moderate Attitude	233	.58	.28	5.61	$p<.001$
Extreme Attitude	392	.44	.32		

Integrative Complexity and Attitude Extremity

This research objective explored the relationship between attitude extremity and integrative relationship. The proposed research objective was to:

R3: Determine if respondents' extreme attitudes toward prescribed fire are characterized by different levels of integrative complexity than moderate attitudes.

Results of the independent samples *t*-test suggest that respondents with a moderate attitude had a higher mean level of integrative complexity (M = .58, SD = .28) than those with an extreme attitude (M = .44, SD = .32). These results, $t(537) = 5.61$, $p < .001$, d = .46, were significantly different (Table 22).

Correlation Between Belief Indices and Integrative Complexity

This objective explored if there was a relationship between the basic belief indices and integrative complexity. The proposed research objective was to:

R4: Determine if there was a significant correlation between respondents' level of integrative complexity and wildland fire management basic belief indices.

Baron and Kenny (1986) observe that it is highly desirable that the moderator is uncorrelated to the basic belief indices. No significant correlational relationship was found between integrative complexity and the belief indices used in this analysis (Table 23).

Table 23

Relationship Between Integrative Complexity and Basic Belief Dimensions: Pearson's Correlation

Basic Belief Dimension	*r*	*p*-value
Trust[a]	-.014	.728
Ecocentric Forest Belief	.041	.299
Anthropocentric Forest Belief	-.101	.010*
Fire Suppression[a]	.028	.479
Natural Fire	.049	.212
Responsibility[a]	.050	.205
Freedom[a]	-.024	.549
Recreation Limits	-.026	.516
Economic Use	-.008	.842

*Correlation significant at $p < .01$.
[a]Variables included in the moderation analysis.

Moderating Effects of Integrative Complexity

The research objective examined in this analysis was:

R5: Determine if the relationship between basic beliefs about wildland fire management and attitudes toward prescribed fire are moderated by integrative complexity.

This regression analysis explored the moderating effects of integrative complexity on the relationship between the Freedom, Trust, Responsibility, and Fire Suppression basic beliefs and attitudes toward prescribed fire. Twelve separate regression analyses were conducted, three for each independent variable. Moderation occurred in two of the four interaction terms (Table 24).

Table 24

Regression Analysis for the Moderating Effects of Integrative Complexity (IC) on the Basic Belief-Attitude Relationship

Independent Variables[b,c]	*B* Coefficients[a]			R^2	*F*-value
Freedom	.08**	--	--	.010	6.85
Freedom, IC	.08*	.13***	--	.033	10.50
Freedom, IC, Freedom*IC	.16*	.20**	-.03	.036	7.57
Trust	-.23***	--	--	.063	46.51
Trust, IC	-.25***	.12***	--	.094	31.86
Trust, IC, Trust*IC	-.57***	-.45***	.11***	.124	28.89
Responsibility	.06	--	--	.004	2.53
Responsibility, IC	.03	.12***	--	.022	6.85
Responsibility, IC, Responsibility*IC	-.001	.09	.01	.022	4.63
Fire Suppression	.29***	--	--	.110	86.59
Fire Suppression, IC	.31***	.12***	--	.137	49.03
Fire Suppression, IC, Suppression*IC	.54***	.37***	-.08***	.154	37.42

* indicates significance at p < .05, **indicates significance at p < .01, *** indicates significance at p < .001

[a] Dependent variable was the Prescribed Fire Attitude Index

[b] None of the independent variables showed a Pearson's correlation >.90. Multicollinearity diagnoses were not conducted.

[c] Three separate regression analyses were conducted for each independent variable: independent variable; independent variable and integrative complexity; independent variable, integrative complexity, and the interaction term.

The moderated interaction terms were Trust, $B = .11$, $t\,(615) = 4.57$, $p < .001$, and Fire Suppression, $B = -.08$, $t\,(617) = -3.52$, $p < .001$. The variances for these two predictors increased

and the interactions were significant at $p<.001$. However, the variance explained by the model was low. This was 12% for Trust and 15% for Fire Suppression.

The following four figures graphically display the results for each analysis (Figures 6-9).

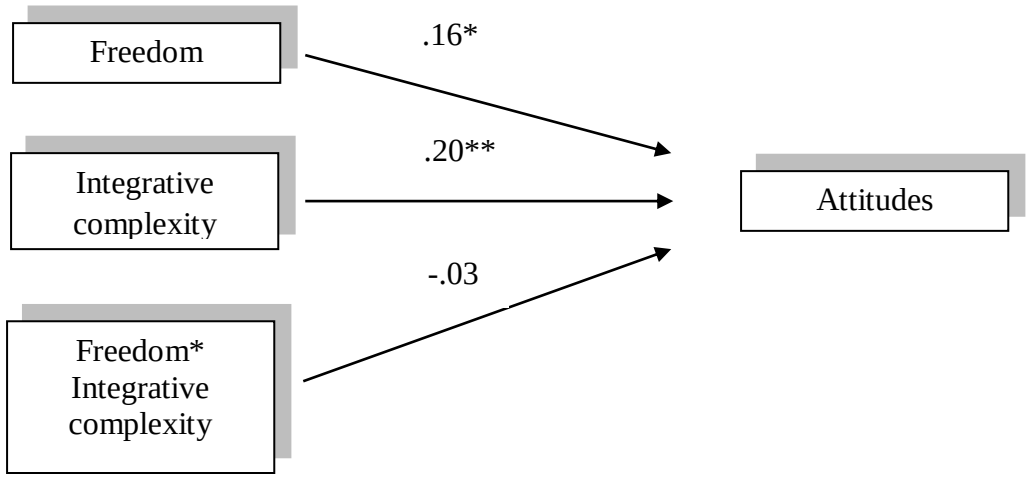

Figure 7. Integrative Complexity Moderation Results for Freedom and Prescribed Fire Attitudes.

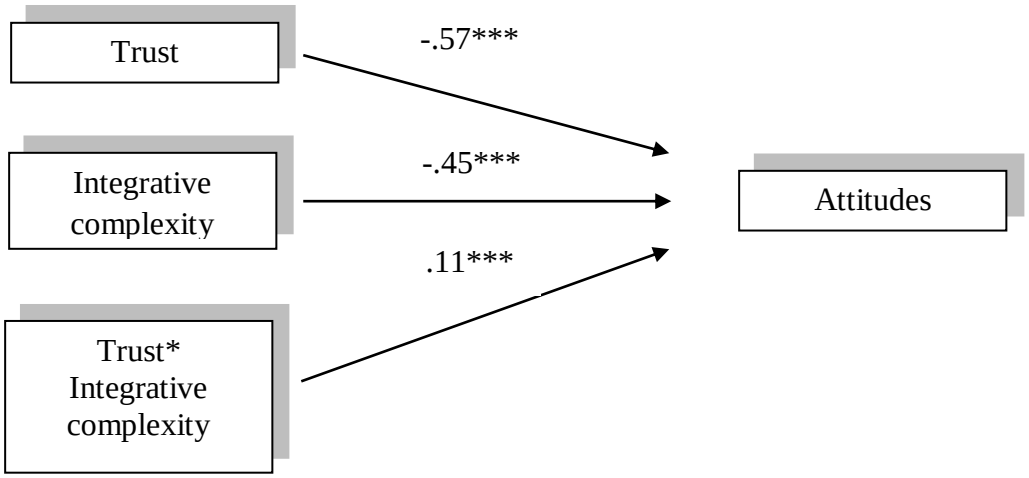

Figure 8. Integrative Complexity Moderation Results for Trust and Prescribed Fire Attitudes.

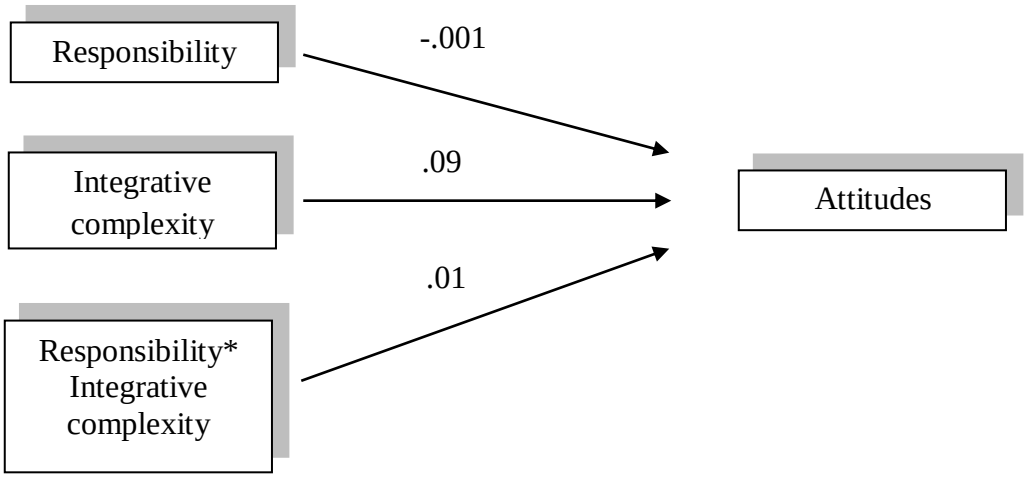

Figure 9. Integrative Complexity Moderation Results for Responsibility and Prescribed Fire Attitudes.

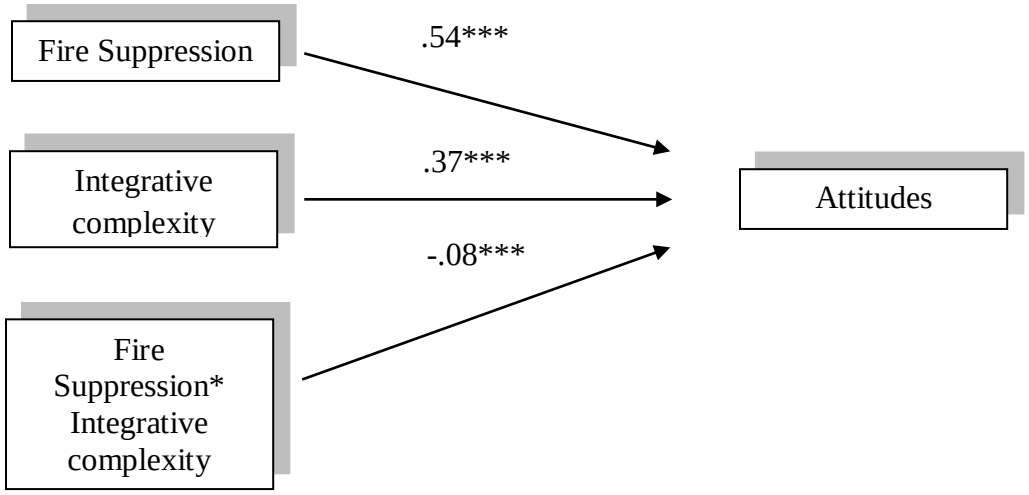

Figure 10. Integrative Complexity Moderation Results for Fire Suppression and Prescribed Fire Attitudes.

The moderation criteria established by Baron and Kenny (1986) was met. As previously identified by Carroll and Bright (2009), integrative complexity may function as a moderator for the basic belief-attitude relationship. Analysis also included the nature of integrative complexity's moderating effects (Table 25). The high and low integrative complexity groups were compared on the relationship between basic beliefs and attitude. Results suggest that both trust and fire suppression explained more of the variance in attitude (16% and 17%, respectively) for the low integrative complexity group than for the high integrative complexity group (2% and 7% respectively).

Table 25

Comparison of High and Low Integrative Complexity on the Basic Belief-Attitude Relationship

	Integrative Complexity Group			
	Low		High	
Basic Belief Dimension	R^2	*B*	R^2	*B*
Trust	16%	-.39***	2%	-.10*
Fire Suppression	17%	.42***	7%	.21*

* indicates significance at $p < .05$, *** indicates significance at $p < .001$

CHAPTER 5

Conclusions and Discussion

The purpose of the investigation was to determine respondents' level of thought complexity toward prescribed fire and apply it to a conceptual framework in order to assist agencies in developing prescribed fire-related policies, management actions, and communication strategies. Taken together, study results suggest that integrative complexity is an appropriate methodology to identify how individuals think about an issue such as prescribed fire. This study used a relatively new methodology to measure integrative complexity (Carroll & Bright, 2009, 2010). This new methodology, while building upon similar wildland fire-related research, was applied to a new research scenario. In general, results regarding integrative complexity are consistent with previous research. This information will be presented in the following sections: (1) summary of procedures, (2) summary of findings, (3) conclusions and implications, and (4) recommendations for further research.

Summary of Procedures

Data Collection

Data for this study were collected from November, 2011, to January, 2012, through mail surveys sent to a random sample of households in three study areas, located in northern Colorado and southern Wyoming. Key variables that were measured included beliefs about forests, fire, fire management, and trust in the USFS, as well as attitudes toward prescribed fire. The total number of valid assessments returned was 783, an overall response rate of 18%. Since the purpose of the dissertation was to test theoretical relationships between social psychological constructs, this was not seen as a detriment and no test was conducted for nonresponse bias.

Treatment of Data

Several testable models were developed to (1) examine the relationship between integrative complexity and attitude direction and extremity and (2) explore the moderating effects of integrative complexity on the relationship between several wildland fire-related basic belief indices and attitudes toward prescribed fire. A dichotomous variable was created for integrative complexity and scaled variables were created for both integrative complexity and attitudes toward prescribed fire. A principal components analysis was used to develop the wildland fire-related basic belief indices.

Creation of Indices

The principal component analysis identified eight clusters within the assessment's belief sections. These were Ecocentric Forest Beliefs, Anthropocentric Forest Beliefs, Fire Suppression, Natural Fire, Responsibility, Freedom, Recreation Limits, and Economic Use. Two indices, Trust and Prescribed Fire, were not developed by using the principal components analysis. These indices had four or fewer belief statements in the original assessment. Cronbach's alpha was used to test the internal consistency of each index. All indices had adequate scores.

Data Analysis

In order to examine each research objective, the following statistical tests were conducted:

R1: Descriptive statistics, crosstabulation, and analysis of variance (ANOVA), with post-hoc tests were used to examine perceptions toward MPB and whether there were any demographic influences in respondents' levels of integrative complexity.

R2 and **R3**: Independent samples *t*-tests were used to examine the relationship between integrative complexity and attitude directions and extremity.

R4: Pearson's correlations were used to examine the relationship between integrative complexity and the trust, freedom, responsibility, and fire suppression belief indices.

R5: Regression analysis was used to explore the moderating effects of integrative complexity on the relationship between basic belief indices and integrative complexity. Moderation analysis was conducted separately for each belief dimension. Three regressions were conducted in each analysis. First, the prescribed fire attitude index (DV) was regressed on the belief dimension (IV). Next, attitude was regressed on the belief dimension and integrative complexity 5-point Likert scale. Finally, attitude was regressed on the belief dimension, integrative complexity scale, and a multiplicative interaction of these two independent variables.

This chapter will follow the same structure as Chapter 4. The first section is discussion of the results for the demographic analysis. The following sections will discuss the research objectives focusing on integrative complexity.

Demographic Analysis

The demographics suggest that the respondent sample provided a representation of gender, age, education, and income. Responses did not represent a sample population that was predominantly male, retired, and upper income. As identified by Tables 3-8, this suggested an appropriate distribution within each applicable demographic category.

In general, the Northern study group results were different than the other two groups. This study location included counties in northern Colorado and southern Wyoming. Results suggest that this sub-strata lived for a significantly longer amount of time in current residences, as well as in Colorado or Wyoming, than the other two groups. This difference was statistically

significant (Table 3). Further, there were a higher percentage of respondents over 70 years of age from the Northern study area (23.2%), than there were from the Front Range (11.9%) or Central (15.3%) locations. That is consistent with the results of the length of residence section. There were two other areas of interest. Regarding education, a higher number of Northern study area respondents possessed high school, technical, vocational, or associate degrees (42.9%) than either the Front Range (26.8%) or Central (27.1%) locations. It should be noted that the Northern respondents had a higher percentage of individuals holding one or more graduate degrees (25.7%) than the Central group (20.4%), but not the Front Range group (32.4%).

This group of respondents also resides in communities and counties that, in general, tend to be smaller in population and/or more rural in character than the other two sub-strata. Though not tested, differences between the three study locations could be attributed to historic land use, settlement, employment, or other factors.

A final demographic analysis examined the frequencies of the integrative complexity Likert scale and dichotomous *high* and *low* variables. Tetlock (1989) suggests that in a given sample, it is not unusual for 50% or more of the integrative complexity scores to be at the lowest scale value. In the 5-point Likert scale, 39.8% of respondents scored *very low* or *low*, while 60.3% of respondents scored *very low*, *low*, or *moderate*. For the *high* and *low* scores, 48.6% of respondents scored *low*, while 51.4% scored *high*. In general, these results support Tetlock's observations from previous research. Tetlock (1989) suggests that people, all other things being equal, generally prefer integratively simple styles of reasoning. This requires little mental effort and makes few emotional demands.

Perceptions of MPB and Demographic Influence of Integrative Complexity

This objective examined public perceptions of the mountain pine beetle's impact on wildland fire management. Results suggest that, in general, respondents favor the use of prescribed fire, understand the role of fire on the landscape, and support management practices to reduce the risk of wildfires. These findings provide a current baseline from which forest managers can build outreach and education initiatives. These results also suggest that respondents believe owners are primarily responsible for protecting their property, not an agency. As supported by previous studies and anecdotal evidence, there was little support for restrictions on building adjacent to, or in, areas at risk for wildfire (National Fire Protection Association, 2011).

Prescribed fire results were compiled at the sub-strata level. Specific locations were not analyzed in this study. Previous research suggests that individuals, in general, may favor prescribed fire. Acceptability is judged within a geographic context (Kneeshaw, Vaske, Bright & Absher, 2004). Attitudes potentially change when individuals are asked to accept specific management actions, including prescribed fires, near their residence or property (Bright & Newman, 2006). The attitude responses show another trend for the Northern respondents to be different than the other two groups. In each prescribed fire attitude assessment, Northern respondents were more negative than the other two locations (Tables 9-11). These respondents also demonstrated a lower level of trust for USFS managers (Tables 17-18). Previous research suggests trust plays an instrumental role in support for forest management actions (Lijeblad et al., 2002; Winter, Absher, & Watson, 2007; Winter, Vogt, & McCaffrey, 2004). Since prescribed fires are planned and executed by agencies, this may explain the negative attitudes by this

respondent group. As discussed later in this chapter, results indicate that integrative complexity moderated the relationship between trust and attitude toward prescribed fire.

This objective also examined whether there were differences in the level of integrative complexity based on study location or demographics. Potential differences between the study locations were examined using both the integrative complexity Likert scale and *high* and *low* variables. No significant differences were found.

Potential demographic-related differences in integrative complexity were examined, based on income, education, and gender. No significant differences were found within income levels. Regarding education, previous research suggests that individuals can be prompted to increase their thought complexity (Bright & Barro, 2007; Bright & Wyche, 1998; Hunsberger et al., 1992; Tetlock, 1989). Based on the increased cognitive domain found in graduate-level education, such as *analysis* and *synthesis* (Krathwohl, 2002), levels of education were compared. No significant differences were found. Though not identified in previous research, results suggested gender differences in integrative complexity. It should be noted, however, that these differences were statistically marginal. Based on the probability values and effect sizes, there may be no practical significance (Vaske, 2008).

Integrative Complexity and Attitude Direction

Lack of a significant relationship between attitude direction and integrative complexity was consistent with previous research (Bright & Barro, 2000; Burtz & Bright, 2007; de Vries & Walker, 1987; Tetlock, 1989). However, Carroll and Bright (2009) found a significant relationship between attitude direction and integrative complexity in a study of perceptions toward wildfire management. Though not tested, the authors suggest this finding may have been

due to prescribed fire-related safety concerns, limiting the complexity with which people with negative attitudes view the issue.

Integrative Complexity and Attitude Extremity

Results were consistent with previous research that found a significant relationship between attitude extremity and integrative complexity (Bright & Barro, 2000; Bright & Manfredo, 1996; Burtz & Bright, 2007; Carroll & Bright, 2009; de Vries & Walker, 1987; Linville, 1982; Tetlock, 1989). Individuals who recognize the tenability of competing sides to an issue are more likely to have more moderate attitudes about the topic than those who view the same issue in simplistic, black and white terms (Carroll & Bright, 2009; Linville, 1982). The practice of prescribed fire provides an excellent example. An individual may be able to recognize the positive aspects of prescribed fire, such as clearing built-up fuels, replenishing nutrients in the soil, and having a lower cost than mechanical thinning. At the same time, the same individual may believe that prescribed fire results in poor visibility, releases harmful particulates, and is subject to the potential loss of control.

Correlation Between Belief Indices and Integrative Complexity

Results are consistent with previous research that found no relationship between values and integrative complexity (Bright & Barro, 2000; Carroll & Bright, 2009). Carroll and Bright (2009) suggest that values, expressed through basic beliefs, are developed early in life (Fulton et al., 1996; Rokeach, 1973; Vaske, 2008), while cognitive style, such as complexity of thought, develops later and may be situational (de Vries & Walker, 1987). The specific and situational nature of prescribed fire may impact an individual's thinking as much or more than values.

In addition, results were consistent with Baron and Kenny's (1986) observation that it is highly desirable that the moderator is uncorrelated to the basic belief indices. This allows a

clearly interpretive interaction term. It should be noted that the Pearson's *r* between the moderator variable (integrative complexity) and the dependent variable (prescribed fire attitude) was significant ($r = .155$, $p < .001$). However, since $r < .90$, no collinearity issues are assumed (Vaske, 2008).

Moderating Effects of Integrative Complexity

Results supported integrative complexity as a moderator for the relationship between values and attitude toward prescribed fire. The values were operationalized as basic beliefs about wildland fire and management. As defined by Baron and Kenny (1986), the moderator variables affected the direction and/or strength of the relationship between the independent (predictor) variables and the dependent (criterion) variable. The regression line changed with the addition of both the Trust and Fire Suppression interaction variables. An increase in the Trust interaction variable results in an increased positive attitude toward prescribed fire. Intuitively, this makes sense. The greater the trust in a land management agency, the more positive the attitude toward prescribed fire. Regarding the other significant interaction variable, an increase in the Fire Suppression interaction variable also results in an increased positive attitude toward prescribed fire. It could be expected that the interaction variable would enhance support for prescribed fire. If an individual favorably views fire on the landscape, that individual may approve of prescribed fire as a management tool. However, the small correlation between both sets of variables suggests a weak linear association.

The value-laden beliefs regarding trust and fire on the landscape explained more of the variance in attitude toward prescribed fire with the *low* integrative complexity group, than for the *high* integrative complexity group. In previous research, Carroll and Bright (2009) suggest that when attitudes are based on one or a few dimensions, as in the case of low integrative

complexity, the nature of that attitude is more likely to be ascertained than for issues where an individual's attitude is formed by a larger number of potential diverse dimensions.

Similar to the study conducted by Carroll and Bright (2009), this study found that moderation depends on the value considered. In this analysis, integrative complexity moderated the relationship between attitude toward prescribed fire and the value-laden basic beliefs of Trust and Fire Suppression. No moderation was found for the value-laden basic beliefs of Freedom and Responsibility. While this study found moderation for Trust and Fire suppression, a previous study by Carroll and Bright (2009) found moderation for Trust, Freedom, and Artificial Manipulation. Artificial Manipulation was not analyzed in this study.

By studying the relationship between values and attitudes, this analysis supported recommendations for expanding upon previous studies of the relationship between attitudes and behavior (Burtz & Bright, 2007). It also fit the framework suggested by Baron and Kenny (1986) to identify the correlational and experimental components of a moderator. As found in Figure 2, the model has three causal paths, with the interaction path, Path *c*, being significant. Two other considerations suggested by Baron and Kenny (1986) are also met. First, there was no correlation between the moderator variable (integrative complexity) and predictor variables. Second, the moderator and predictor variables were all causal variables exogenous to any criterion effects.

Sample Limitations

The number of overall valid responses (N = 783) for the public perceptions assessment was lower than anticipated. However, this was not considered to be a negative factor for the dissertation, since the purpose of the research was to test theoretical relationships between social psychological constructs. Analysis of the respondents' ages, education, and income suggest that

the study was able to obtain responses from a demographic cross section (Tables 3-8). This may reduce any potential non-response bias.

Several factors may have contributed to the small sample. The assessment, developed through a collaborative process, was 12 pages, including a complex mapping component. During the pre-test, completion times ranged from 16 to 30 minutes. A lengthy completion time may have discouraged certain respondents. The mapping section itself may also have been a deterrent for certain respondents. However, analysis found that 54% of respondents returned the assessment without completing the map. This suggests that the mapping component was not a deterrent for the general sample population. There are two additional reasons why households did not participate. Fragmentation may have occurred. Households on the mailing list may not have knowledge of, or experience in, the adjacent study area. For example, a Fort Collins household may have no knowledge of the Front Range study area. Though not examined, it is also possible that the mailing list included second homeowners who did not participate.

Implications

The research could potentially have implications in several areas. These include societal, theoretical, and managerial, including the Joint Fire Science Program.

Societal Implications

Romme et al. (2006) observe that it generally takes 20 to 50 years for the development of new forests after an MPB outbreak. During that period, there are numerous societal implications. Information needs to be tailored to the target audience, incorporating the appropriate communicator, content, and method.

The integrative complexity study data included an assessment of how people perceive the MPB infestation in Colorado and Wyoming. Results can be communicated to the public,

allowing dialogue and conversation about how we collectively view not only the forest ecosystem, but also wildland fire management. The complex nature of wildland fire management lends itself to agency and public discussion and collaboration with the public.

Theoretical Implications

The research model suggests continued application, in general, for natural resource-related social science research. It is applicable for those subjects which may be considered dichotomous in nature. Potential subjects may include wildland fire management for WUI communities adjacent to designated wilderness areas, controversial wildlife management issues (e.g., wolf reintroduction), and certain resource extraction practices, such as hydraulic fracturing.

Managerial Implications

One potential implication of this research will be its application by the USFS and other natural resource management agencies. The study originated due to the interest of the Arapaho-Roosevelt National Forest (NF) forest supervisor in the public's perception of the MPB cycle. He was later joined by the supervisors of Medicine Bow-Routt and White River NF's. This methodology may be of interest to other agencies dealing with natural resource management issues requiring public participation. A strength of the study is that the methodology potentially allows agency communication, education, and collaboration efforts to be tailored, at the appropriate level of detail and complexity, to specific audiences.

Joint Fire Science Program. The wildland fire community recognizes the criticality of social science/human dimensions research (Jakes, 2007; Kobziar et al., 2009). This includes subjects ranging from the expanding WUI to leadership and management of wildland fire organizations. The continued social science requirements identified by the USFS Research

Stations, Joint Fire Science Program, and other agencies confirm this trend (Haynes, McCaffrey, & Prestemon, 2007).

The conceptual model strongly supports two research focus areas identified by the Joint Fire Science Program (JFSP) within the past year (JFSP, 2011). These are the (a) articulation of new concepts or frameworks and (b) field activities involving diverse scientists, policy-makers, managers, and citizens. The concept model represents a new framework for further research. The system components can be applied to other complex situations encountered in a larger scale. The adaptive management model could potentially be used as an agency response in this environment. Use of the integrative complexity scale is a relatively new research concept which has continued potential in fire social science. The field activities, involving diverse participants, are closely aligned with the concept model. All of the participants identified in the JFSP request for applications are found within the various system components. The current fire season demonstrated the relevance of fire social science research. Based on projections for increasing fire activity in the future and the continued growth of the WUI, there is every reason to believe that social science research will remain an area of emphasis.

Continued research on the MPB disturbance may be an appropriate subject for a JFSP proposal. Applying the concept model to another disturbance-related event, with wildland fire implications, could be considered. The pinyon ips beetle outbreak, currently located in six southwestern U.S. states, may be an appropriate framework (Nikiforuk, 2011).

Recommendations

This study examined a newly-developed social science measuring scale, applied to a natural resource management issue. While concentrating on a theoretical relationship among the social psychology constructs of values and attitudes (Burtz & Bright, 2007), this study has

application for natural resource management decisions and policy development. This chapter presents recommendations for both the theoretical and applied aspects of this study.

Theoretical Recommendations

Application to different scenarios. The measurement scale is a relatively new development, with limited application in research (Carroll & Bright, 2010). This study replicated previous research by examining integrative complexity in a wildland fire environment (Burtz & Bright, 2007; Carroll & Bright, 2009). However, as recommended in those studies, this analysis applied the scale to a different scenario. In this study, MPB served as a disturbance agent in the three Colorado and Wyoming study locations. Continued research should apply the measurement scale to different wildland fire-related scenarios. The 2012 wildland fire season in Colorado, including the Lower North Fork, High Park, and Waldo Canyon Fires, identified several potential research subjects for applying the measurement scale. These include home or property owner responsibility for fuels mitigation in the WUI, smoke management, and land management agency fuels mitigation and fire suppression responsibilities in and around the WUI. Another subject is the continued study of prescribed fire as a management tool. Further research would also allow a comparison with owner responsibility, fuels mitigation, and fire suppression research conducted prior to the 2012 fire season. Each of these subjects can be contentious, facilitating the use of the measurement scale.

Use of different leading questions. This study generally replicated the structure of the integrative complexity leading question used by Carroll and Bright (2009). However, I agree with the authors' suggestion of exploring a different leading question to ensure that the different dimensions are, or are not, being identified. This may result in the use of a different concept combination of the integration scale. As in that study, this one asked respondents how "strong"

or "weak" they believed their argument to be. Other comparisons may be to ask respondents how "safe/dangerous," or "reliable/unreliable," they believe the practice to be. This may provide for a more direct evaluation of management practices that would provide beneficial information to managers. For quantitative analysis, it is possible the amount of variance explained by integrative complexity would be greater when combined with attitudes and basic beliefs (Carroll & Bright, 2009).

Analysis at different scales. The final theoretical recommendation deals with the sample group for future research. Carroll and Bright (2009) suggested examining the integrative complexity of managers. This allows a better understanding of how managers think about issues, as well as if this level of complexity is consistent with their agency's goals and mission. I concur and would suggest expanding this to examine fire managers and policy directors in the five federal organizations responsible for wildland fire management (Bureau of Indian Affairs, Bureau of Land Management, U.S. Fish and Wildlife Service, National Park Service, and USFS [NWCG, 2012b]).

An analysis could be conducted at various scales (e.g., local, regional, and federal), focusing on individuals responsible for the development and implementation of federal wildland fire policy. This allows a comparison of a manager's complexity of thought at one level with those at another. As Tetlock (1989) observes, this is both difficult and rare. For example, one research objective could be to determine whether a policy manager at the federal level (e.g., USFS headquarters) thinks more complexly than a fire manager at the local level (e.g. national forest). Theory suggests that a federal-level policy manager would have a higher level of complexity, due to an understanding of competing interests and legal implications (Tetlock, 1989). However, a local fire manager must have an understanding of resident's interests and

vulnerabilities, available resources and interagency coordination, landscape-level fire management, and impact on the landscape of suppression tactics (e.g., fire retardant in watersheds and containment lines). As Kobziar et al. (2009) observe, fire managers must have knowledge of fire management, fire ecology, and fire social science. Combined, this is a very complex body of knowledge. Theory may not be applicable in this situation.

Management and Policy Development Recommendations

Public perceptions. The public perceptions component of this study is a descriptive analysis with pertinent information for managers. The integrative complexity component is a theoretical analysis, with potential management and policy implications. For the purpose of this chapter, management and policy recommendations are discussed in the context of the USFS as the implementing organization.

The public perceptions research attempted to provide a baseline measurement for forest managers in agency trust and fire management. In the area of fire management, results suggest continued opportunities for fire social science research. Future research should continue in the assessment of attitudes toward prescribed fires. Analysis should include incorporating distance to the national forest or identifying residences and communities in the WUI to answer specific prescribed fire-related research objectives. Future studies, conducted after the 2012 fire season, can determine if results are comparable or differ from those in this assessment, as well as previous research. Considering the significant public attention toward the recent Lower North Fork escaped prescribed fire (Jefferson County, CO), research could include public knowledge of prescribed fire control mechanisms (State of Colorado, 2012).

One major implication of this study will be its application by the USFS and, potentially, other natural resource management agencies. The USFS intent is to gain an understanding of

how the public perceived the MPB impact and then use this information to assist during forest management planning efforts and to develop tailored communication and collaboration programs with the public. Study results may suggest to USFS managers that the service has a different perspective on an issue than the general public. An understanding of the public's perceptions of an issue is a key element in agency policy development.

Prescribed fires, as a policy tool, are part of the process which feeds back into the iterative adaptive management cycle. Management questions include what are we trying to achieve by this, and other, actions? Are we successful? Is the prescribed fire the right fire, at the right place, at the right time (USFS, 2012a)? Public perceptions of prescribed fires and other managements tools are another critical component used to contribute to adaptive management.

Integrative complexity. The overarching objective of the dissertation research is to provide information that the USFS may use to reduce the risk wildfires present to wildland firefighters and residents in the WUI. By examining the public's complexity of thought about prescribed fires in areas with mountain pine beetle (MPB) infestation, the resulting analysis potentially allows USFS managers to implement management actions which could potentially reduce the risk of a high-intensity, catastrophic wildfire in the future. Education and outreach efforts can be tailored to meet a target audience's level of thought complexity about prescribed fires. As previous research suggests, the controversial and often complex nature of management actions such as prescribed fire makes it important that managers acknowledge the extent to which people are able to understand the intricacy of the issue. The level of complexity behind the public's attitudes toward prescribed fire has implications for the effectiveness of information programs designed to educate or persuade the public (Burtz & Bright, 2007).

For an example, consider a population group that understands several arguments for and against prescribed fire. In general, this group may recognize that prescribed fire recycles nutrients into the soil, removes excess fuels, and may cost less than mechanical thinning in a certain forest landscape. At the same time, this group recognizes that prescribed fire may result in reduced visibility, potentially releases harmful particulates into the air, and could be subject to loss of control. From a public information perspective, managers may focus on the prescribed fire planning and control mechanisms. This is different than the information requirements for a population which objected to any fire on the landscape.

Application of the conceptual model. A system is defined as a complex network of component parts linked by dynamic processes (Limburg et al., 2002). In the conceptual model, reintroduced as Figure 11, there are several components and processes. They include links between (a) an ecological disturbance (MPB and wildfires), (b) that results in USFS organizational adaptation, change, and policy implementation, (c) which includes management at the ecosystem level, potentially incorporating ecosystem services, (d) using two theoretical foundations (*cognitive hierarchy* and *integrative complexity*) for examining public perceptions, (e) and then providing this analysis to the USFS, which communicates and collaborates with the public and stakeholders, flowing back into the decision-making cycle.

An event which may prove well-suited for an application of this research model is the recent High Park Fire in Larimer County. This fire provides an example of a wildfire's impact on the landscape and ecosystem. On July 20, 2012, *The Coloradoan* newspaper published a summary of the High Park Fire Burned Area Emergency Response Team report (High Park Fire Burned Area Emergency Response Team, 2012; Magill, 2012). The team was comprised of

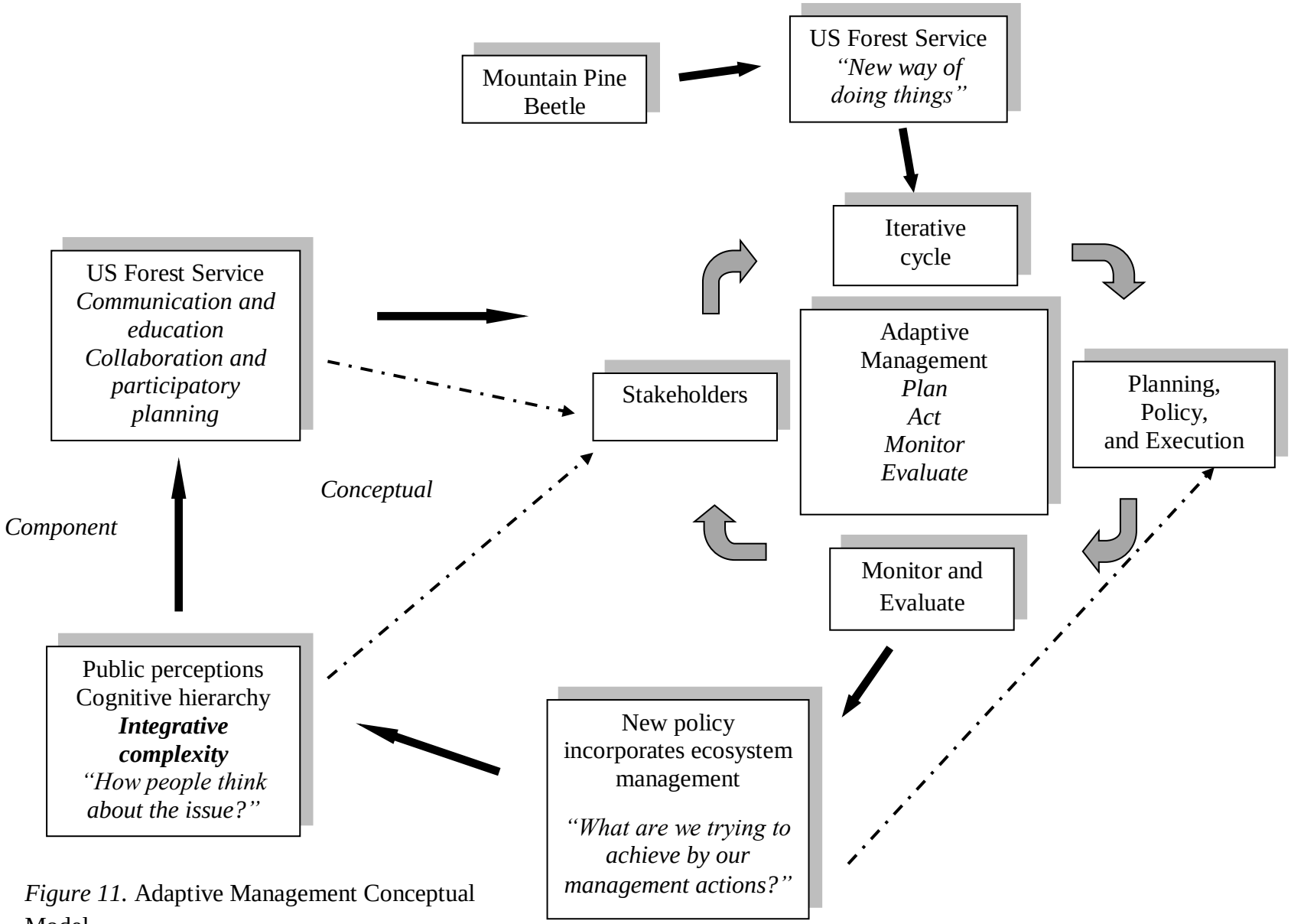

Figure 11. Adaptive Management Conceptual Model.

representatives from the USFS, the federal Natural Resources Conservation Service, Colorado Department of Transportation, and Larimer County.

The burn area will present a risk to human life and the landscape for the foreseeable future. Of the 87,000 acres within the fire's perimeter, 14,000 were unburned, 32,202 burned with low severity, 35,399 burned with moderate severity, and 5,714 burned with high severity. Numerous burned slopes will have to be treated with erosion-reducing mulch, reseeding, and stabilization. The estimated cost for the mulching alone is over $12.5 million. Municipal water supplies for Fort Collins and Greeley are vulnerable to increased sediment and debris flows, with the worst flows expected in the next three to five years. The South Fork of the Poudre River has been significantly impacted by the fire, with sedimentation and rain water runoff expected to severely stress the river for several years. Due to slopes losing vegetation, flooding can also be expected in the near future. The expected percentage increase in the flow of selected streams may range from 183% (Hewlett Gulch) to 4,194% (East Tributary to Pendergrass Creek). Other hazards include (a) residential areas at risk of debris flows, (b) potential damage to, or failure of, roadways, bridges, and culverts, and (c) hiking trails overwhelmed by debris flows. Total restoration costs are expected to exceed $24 million.

Beetle-killed trees were located throughout the High Park Fire's burn area. Analysis continues on the relationship, if any, between beetle-killed trees and fire behavior (Wells, 2012). Another pending assessment is the role that previous fuels treatments, including prescribed fire, had on fire behavior. Initial research conducted by the CSFS suggests that fire behavior during the High Park Fire was moderated in areas where prescribed fires and mechanical thinning were previously conducted (CSFS, 2012). The review team for the 2010 Four Mile Canyon Fire in Boulder County, CO, found that fuels which could have been removed through prescribed fires

contributed to the high fire intensities and fire spread rates observed during the fire. The team found that if low-intensity prescribed fires had been applied within the 6,181-acre burn area at frequent (e.g., 10 year) intervals, they would have consumed litter layers, killed shrubs and small trees (e.g., ladder fuel), and pruned the lower branches of trees. This lessens the occurrence of trees torching and may reduce fire progression (Rocky Mountain Research Station [RMRS], 2011).

The High Park Fire represents a complex, landscape-scale event incorporating both natural resource and social science implications. Similar to the situation facing the USFS' bark beetle IMO, any agency-related efforts to manage the wildfire's impact will be both long term and involve multiple government and private collaborative partners, including the general public. This study's conceptual model, which includes organizational management, policy development, ecosystem management and services, public perceptions, and public interaction, can potentially provide agencies a template to deal with an event of this scale. The applied aspect of this research will be measured by whether it can support USFS and other agency research needs and future applications meeting fire social science requirements.

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APPENDIX A

Basic Belief Dimensions: Principal Component Analysis

Basic Belief Dimensions: Principal Component Analysis

Belief dimensions[a]	Factor Loadings[b]			
	Factor 1 (Ecocentric)	Factor 2 (Anthropo-centric)	Factor 3 (Fire Suppression)	Factor 4 (Natural Fire)
Forests have as much right to exist as people	.91			
Nature has as much right to exist as people	.90			
Wildlife, plants, and people have equal rights to exist	.80			
Forests have value whether people are present or not	.60			
Primary value of forests is to provide timber, grazing land, or minerals		.77		
Primary value of forests is to provide places to recreate		.77		
Nature's primary value is to provide products for people		.72		
Forests are valuable only if they provide jobs and income		.63		
We should not allow forest fires to destroy wildlife and habitat			.81	
Forest fire should be put out if endangering wildlife and habitat			.78	
Losing wildlife and habitat is an acceptable result of allowing natural fires[c]			.70	
It is OK if some wildlife is lost to forest fires due to overall forest health[c]			.68	
Forest fires should be put out if they are going to destroy scenery			.63	
Forest fire put out if decreases recreational opportunities in an area			.59	
Forest fires started by lightning should be allowed to burn if controlled[c]				.89
Forest fires started by lightning should be automatically put out				.61
Forest fires should be allowed to burn naturally even if scenery will be destroyed[c]				.58

[a] Items coded on a 7-point scale from 1 = Strongly disagree to 7 = Strongly agree.
[b] Factor loadings >.40 are shown.
[c] Recoded variables

Basic Belief Dimensions: Principal Component Analysis (Cont'd)

Belief dimensions[a]	Factor Loadings[b]			
	Factor 5 (Responsibility)	Factor 6 (Freedom)	Factor 7 (Recreation Limits)	Factor 8 (Economic Use)
When people build near national forests managers are primarily responsible to ensure private homes are protected	.82			
People who build near national forests have the right to expect their home to be protected from fire by land managers	.75			
Managers are primarily responsible for ensuring adjacent private property is not destroyed	.70			
People who build homes near national forests are primarily responsible for protecting homes[c]	.69			
When people build homes near national forests, it is their fault if their homes are damaged by fire[c]	.59			
People should not be allowed to build homes near forests where they could be destroyed by fire		.89		
There should be laws against building homes adjacent to a national forest where they could be damaged by fire		.87		
People should be allowed to build homes near forests where fire could destroy them[c]		.84		
People who recreate in national forests should accept that some places may not be accessible			.93	
People that recreate in national forests should accept that some activities may be restricted or no longer possible			.91	
Land managers know how to effectively manage tress that potentially pose a risk to people recreating			.53	
Land managers should facilitate the economic utilization of trees killed by the mountain pine beetle				.84
Land managers should use trees killed by the mountain pine beetle for wood products and biomass				.84

[a] Items coded on a 7-point scale from 1 = Strongly disagree to 7 = Strongly agree.

[b] Factor loadings >.40 are shown.

[c] Recoded variables

APPENDIX B

Assessment: Public Perceptions of the Mountain Pine Beetle Impact in Northern Colorado and Southern Wyoming

Public Perceptions of the Mountain Pine Beetle Impact in Northern Colorado and Southern Wyoming

Administered by

The Department of Human Dimensions of Natural Resources &
the Colorado Forest Restoration Institute,
Colorado State University

Your help in this study is greatly appreciated!

This survey is for residents over 18 years of age. We are interested in ALL opinions. Please complete this survey regardless of how much you know or don't know about national forests and their management. The control number is for administrative purposes only. It is used to ensure you don't receive the survey a second time.

We are interested in your views of the how the mountain pine beetle (MPB) infestation has affected your local national forest (NF). Based on your perception of the MPB, please read the following sections and respond to each question.

PLEASE START THE SURVEY HERE…

Part A. ***In this section, we would like to learn about your familiarity with the local national forest.***

1. About how many times during the past 12 months have you visited the national forest? If you are unsure about the boundary of this NF, see the enclosed national forest survey map. ***(Check your response)***

_____None _____1 or 2 times ____3 to 5 times ____6 to 10 times _____More than 10 times

2. Please check the recreational activities in which you have participated in your local NF.

_____Driving for pleasure	_____Fishing	_____Backcountry skiing
_____Hunting	_____Wildlife viewing	_____Snowmobiling
_____Horseback riding/packing	_____Picnicking	_____Tent camping
_____RV camping	_____Rock climbing	_____Mountaineering
_____Four wheeling/Jeeping	_____ATVing	_____Rafting/Kayaking
_____Nature enjoyment	_____Motorcycling	_____Mountain biking
_____Ice climbing	_____Alpine skiing	_____
_____Hiking/Backpacking	_____Backcountry alpine touring	_____Seed or mushroom collecting
_____Snowshoeing	_____Christmas tree cutting	_____Other _____

Part B. ***Beliefs about Fuels Management.*** One common fuels management technique is *prescribed burning*.

We are going to ask you to list arguments both FOR and AGAINST prescribed burning as a technique for managing lodgepole pine forests and the possibility of wildfires. In these forests, fires naturally occur infrequently (on average between 100 and 250 years) and tend to be high-intensity fires, usually crown fires, that kill the majority of trees. These fires are naturally followed by development of a dense, young stand.

- In **column A** please list any arguments **for** (Section 1) or **against** (Section 2) prescribed burning. *Please list as many as you can, although you need not fill the page.*

For example: If you were responding to an issue such as "building a new ballpark for the Colorado Rockies Baseball Team"; for arguments for you might respond, building a new ballpark would "increase revenue for the team" and "make going to a game more fun". For arguments against you might respond that building a new ballpark would "cost the public money" and "result in too much downtown traffic". (This is a hypothetical example).

- In **column B**, indicate how **WEAK** or **STRONG** you think *each* argument you listed is. *Circle the number that represents your response.*

COLUMN A List Arguments **FOR** and **AGAINST** prescribed burning in lodgepole pine forests	***COLUMN B*** How **WEAK** or **STRONG** do you think this argument is?						
***Section 1*: Arguments FOR prescribed burning (LIST AS MANY AS YOU CAN)**	**Extremely Weak**	**Moderately Weak**	**Slightly Weak**	**Neutral**	**Slightly Strong**	**Moderately Strong**	**Extremely Strong**
1._____	1	2	3	4	5	6	7
2._____	1	2	3	4	5	6	7
3._____	1	2	3	4	5	6	7
4._____	1	2	3	4	5	6	7
5._____	1	2	3	4	5	6	7
***Section 2*: Arguments AGAINST prescribed burning (LIST AS MANY AS YOU CAN)**							
1._____	1	2	3	4	5	6	7
2._____	1	2	3	4	5	6	7
3._____	1	2	3	4	5	6	7
4._____	1	2	3	4	5	6	7
5._____	1	2	3	4	5	6	7

We would like to know, IN GENERAL, what you think about PRESCRIBED BURNING in lodgepole pine forests. For each of the questions below, circle the number that best reflects what you think of these forest management strategies.

Do you think that using PRESCRIBED BURNING in a lodgepole forest is …							
	Extremely Wise	Moderately Wise	Slightly Wise	Neutral	Slightly Foolish	Moderately Foolish	Extremely Foolish
… A WISE or FOOLISH strategy?	1	2	3	4	5	6	7
	Extremely Effective	Moderately Effective	Slightly Effective	Neutral	Slightly Ineffective	Moderately Ineffective	Extremely Ineffective
… EFFECTIVE or INEFFECTIVE at reducing the dangers of wildfire?	1	2	3	4	5	6	7
	Extremely Beneficial	Moderately Beneficial	Slightly Beneficial	Neutral	Slightly Harmful	Moderately Harmful	Extremely Harmful
… BENEFICIAL or HARMFUL to the health of the forest?	1	2	3	4	5	6	7

Part C. ***Beliefs about forests.*** People have different reasons for thinking that forests are important in our society. Indicate below how strongly you AGREE or DISAGREE with *each* of the following statements. While some statements may sound similar, please read and respond to each of them. *Circle the number of your response for each statement.*

	Strongly Disagree	Moderately Disagree	Slightly Disagree	Neutral	Slightly Agree	Moderately Agree	Strongly Agree
1. Nature has as much right to exist as people.	1	2	3	4	5	6	7
2. Forests have as much right to exist as people.	1	2	3	4	5	6	7
3. Forests have value whether people are there or not.	1	2	3	4	5	6	7
4. Wildlife, plants, and people should have equal rights to live and develop.	1	2	3	4	5	6	7
5. The value of forests exists only in the human mind; without people, forests have no value.	1	2	3	4	5	6	7
6. Nature's primary value is to provide products useful to people.	1	2	3	4	5	6	7
7. The primary value of forests is to provide places to play and recreate.	1	2	3	4	5	6	7
8. The primary value of forests is to provide timber, grazing land, and minerals for people who depend on them for their way of life.	1	2	3	4	5	6	7
9. Forests are valuable only if they produce jobs and income for people.	1	2	3	4	5	6	7

Part D. ***Beliefs about fire.*** Now we would like to ask you the extent to which you AGREE or DISAGREE with statements about fire. While statements may sound similar, please read and respond to each of them. Again, *circle the number of your response for each statement.*

	Strongly Disagree	Moderately Disagree	Slightly Disagree	Neutral	Slightly Agree	Moderately Agree	Strongly Agree
1. If a forest fire is endangering wildlife and its habitat, the fire should automatically be put out.	1	2	3	4	5	6	7
2. It is OK that some wildlife is lost due to forest fire since fire benefits the overall health of the forest.	1	2	3	4	5	6	7
3. Forest fires should be put out if they are going to decrease recreation opportunities in an area.	1	2	3	4	5	6	7
4. We should NOT allow wildlife and its habitat to be destroyed by forest fire.	1	2	3	4	5	6	7
5. Forest fires should be allowed to burn naturally even if scenery will be destroyed.	1	2	3	4	5	6	7
6. Forest fires started by people should automatically be put out.	1	2	3	4	5	6	7
7. Losing wildlife and its habitat is an acceptable result of allowing natural fires to burn in forests.	1	2	3	4	5	6	7
8. Forest fires should be put out if they are going to destroy scenery.	1	2	3	4	5	6	7
9. Forest fires started by lightning should be allowed to burn as long as they can be controlled.	1	2	3	4	5	6	7
10. Forest fires started by lightning should automatically be put out.	1	2	3	4	5	6	7
11. Forest fires started by people should be allowed to burn as long as they can be controlled.	1	2	3	4	5	6	7

Part E. ***Beliefs about fire management.*** Now we would like to ask you the extent to which you AGREE or DISAGREE with statements about fire management. While statements may sound similar, please read and respond to each of them. Again, *circle the number of your response for each statement.*

	Strongly Disagree	Moderately Disagree	Slightly Disagree	Neutral	Slightly Agree	Moderately Agree	Strongly Agree
1. Land managers should manage forest conditions to decrease the effects of a forest fire.	1	2	3	4	5	6	7
2. People should be allowed to build homes on private property near forests where homes could be destroyed by fire.	1	2	3	4	5	6	7
3. If a fire breaks out in a national forest, land managers should be primarily responsible for ensuring adjacent private property is not destroyed.	1	2	3	4	5	6	7
4. People who build homes on private land near national forests have the primary responsibility for protecting their own home from forest fire.	1	2	3	4	5	6	7
5. When people build homes near national forests, land managers should have the primary responsibility to make sure private homes are protected from forest fire.	1	2	3	4	5	6	7
6. When people build homes near national forests, they have the right to expect their home to be protected from fire by land managers.	1	2	3	4	5	6	7
7. Land managers should not use measures like prescribed burning to decrease the chance of wildfire in a forest.	1	2	3	4	5	6	7
8. People should NOT be allowed to build homes on private property near forests where homes could be destroyed by fire.	1	2	3	4	5	6	7
9. We should leave forests alone instead of trying to manipulate their conditions.	1	2	3	4	5	6	7
10. There should be laws against building homes adjacent to a national forest where they could be damaged by forest fire.	1	2	3	4	5	6	7
11. When people build homes near national forests, it is their fault if their homes are damaged by fire.	1	2	3	4	5	6	7

Part F. ***Beliefs about the use of forest resources.*** To what extent do you AGREE or DISAGREE with statements about the use of forest resources, considering the mountain pine beetle infestation. *Circle the number of your response for each statement.*

	Strongly Disagree	Moderately Disagree	Slightly Disagree	Neutral	Slightly Agree	Moderately Agree	Strongly Agree
1. Land managers should facilitate the economic utilization of trees killed by the mountain pine beetle.	1	2	3	4	5	6	7
2. Land managers should use trees killed by the mountain pine beetle for wood products and biomass (e.g., energy source) development.	1	2	3	4	5	6	7
3. Trees killed by the mountain pine beetle should be left in the forest.	1	2	3	4	5	6	7
4. Trees killed by mountain pine beetles pose a danger to people that recreate in national forests.	1	2	3	4	5	6	7
5. People that recreate in national forests should accept that some risk may occur due to falling trees.	1	2	3	4	5	6	7
6. People that recreate in national forests should accept that some activities may be restricted or no longer possible (e.g., hiking, camping, picnicking) due to the danger of falling trees.	1	2	3	4	5	6	7
7. People that recreate in national forests should accept that some places (e.g., trails, campgrounds) may not be accessible due to the danger of falling trees.	1	2	3	4	5	6	7
8. Land managers know how to effectively manage trees that potentially pose a risk to people using the forest for recreation.	1	2	3	4	5	6	7
9. Land managers should leave slash (e.g., cut trees and underbrush) and fallen dead trees at recreation sites to assist with forest regeneration.	1	2	3	4	5	6	7
10. Land managers should continue to collect fees at recreation sites with trees killed by the mountain pine beetle.	1	2	3	4	5	6	7

Part G. ***Beliefs about trust.*** One important group of land managers is found within the **United States Forest Service**. The United States Forest Service is responsible for managing most of Colorado's forests. This section asks for your views on the United States Forest Service. Please indicate the extent to which you agree or disagree with each of the following statements. *Circle the number of your response for each statement.*

	Strongly Disagree	Moderately Disagree	Slightly Disagree	Neutral	Slightly Agree	Moderately Agree	Strongly Agree
1. I trust that forest managers know how to effectively conduct prescribed burning in national forests.	1	2	3	4	5	6	7
2. I trust that forest managers know how to respond to naturally caused forest fires in national forests.	1	2	3	4	5	6	7
3. I trust that forest managers know how to effectively manage smoke resulting from prescribed burns.	1	2	3	4	5	6	7
4. I trust that forest managers are doing everything they can to respond to the mountain pine beetle outbreak in national forests.	1	2	3	4	5	6	7

Part H. ***Information sources.***

1. This section asks how you receive information about the mountain pine beetle. Have you received information from any of the following sources about either the mountain pine beetle or issues related to the beetle, such as wildland fire or recreation? *Please circle all that apply.*

A. Neighborhood group (homeowners group, local board, etc.)
B. Neighbors, friends, or family members
C. Media (newspaper, TV, radio, internet)
D. County wildfire specialist
E. Local fire department
F. Colorado State Forest Service
G. US Forest Service
H. Other (*please describe*): _____
I. None of the above, you have not received any information about the mountain pine beetle.

2. Of the sources of information in Part H above, identify YOUR most important three sources of information about the mountain pine beetle or beetle-related issues ***(Place the letter (A – H) of the information source on the lines below. If you circled I above, skip this question).***

	_____	_____	_____	
	1st Most Important Source of Information	2nd Most Important Source of Information	3rd Most Important Source of Information	

Part I. ***In what ways do people value the national forest?***

The national forest holds different values for each person. **We would like to know how important each of the following values of the local national forest is to you and where these values are represented on the map.**

Imagine that you could "spend" $100 to ensure that the national forest is able to maintain its values. You may allocate or spend the $100 in any way you like, but your total spending may not exceed $100. You might spend all $100 on one value (and $0 on all others), or you might spend $50 on one value, $25 on another value, and $25 on yet another value. Remember, the total dollars you spend should equal $100. **(Reference to money is not made to actual money, your own or the land manager's budget).**

$____ **Aesthetic value (A)** – I value this forest because I enjoy the scenery, sights, sounds, smells, etc.

$____ **Biological diversity value (B)** – I value this forest because it provides a variety of fish, wildlife, plant life, etc.

$____ **Cultural value (C)** – I value this forest because it is a place for me to continue and pass down the wisdom and knowledge, traditions, and way of life of my ancestors.

$____ **Economic value (E)** – I value this forest because it provides timber, fisheries, minerals, and/or tourism opportunities such as outfitting and guiding.

$____ **Future value (F)** – I value this forest because it allows future generations to know and experience the forests as they are now.

$____ **Historic value (H)** – I value this forest because it has places and things of natural and human history that matter to me, others, or the nation.

$____ **Intrinsic value (I)** – I value this forest in and of itself, whether people are present or not.

$____ **Learning value (L)** – I value this forest because we can learn about the environment through scientific observation or experimentation.

$____ **Life sustaining value (LS)** – I value this forest because it helps produce, preserve, clean, and renew air, soil, and water.

$____ **Recreation value (R)** – I value this forest because it provides a place for my favorite outdoor recreation activities.

$____ **Spiritual value (S)** – I value this forest because it is a sacred, religious, or spiritually special place to me or because I feel reverence and respect for nature there.

$____ **Subsistence value (Sb)** – I value this forest because it provides necessary food and supplies to sustain my life.

$____ **Therapeutic value (T)** – I value this forest because it makes me feel better, physically and/or mentally.

$100 Total Value Allocation

Part J. In the previous question you told us **what values** are important to you related to this forest. For this question, please identify the places **that represent those values on the enclosed map**. To identify the places that are important to you, follow these steps and see the example below:

1. Look at the value(s) you indicated in Part I: what places do you think of in the national forest? You may mark up to four places (it can be less than four) for each value you indicated in Part I. **Please draw dots with a dark-colored pen directly on the map** to indicate the places that represent your important values.
2. Mark what value that place represents to you by **using the value abbreviations listed on the map and in Part I**.
3. **Give the place you marked a number of 1 through 4**. This is now the value mark.
4. **Write the value mark and the place name in the list below** (see example below). If you don't know the specific name of the place, write down an approximate location, e.g., "creek just south of Pretty Peak."

Example: You indicated Aesthetic Value (A) in Part I as one of your important values related to the local national forest. When you think of Aesthetic Value, you think of two places: Pretty Peak and Golden Pond (imaginary places). You make two dots on the map: one where you think Pretty Peak is located, and you mark it as "A1" for Aesthetic Value, place number 1. You make another dot where you think Golden Pond is located, and you value mark it with "A2," for Aesthetic Value, place number 2.

Tips:

- Please mark dots only for the values for which you allocated money in Part I.
- It is not necessary for you to have visited or used the forest location(s) where you place your dots. Some values may be related to forest use while others are not.

List of Value Locations Marked on the Survey Map					
#	Value Mark	Place Name	#	Value Mark	Place Name
1. **2.**	**Example** **A1** **A2**	**Example** **Pretty Peak** **Golden Pond**	6.		
1.			7.		
2.			8.		
3.			9.		
4.			10.		
5.			11.		

Part K. ***In this section, we would like to learn about you and your community. You will remain anonymous and your answers will be confidential.***

1. What is the zip code of your residence? _____

2. How long have you lived in or near your current residence? _____Years

3. How long have you lived in Colorado and/or Wyoming? _____Years

4. Is the residence where you received this survey your primary residence? ***(Check to your response)*** ____Yes
   No

Continued

5. What is your age? _____Years

6. Are you? ***(Check your response)*** ____Male ____Female

7. What is the highest level of education you have completed? ***(Check your response).***

_____Less than high school diploma _____High school diploma or GED_____Technical/Vocational/Associates

_____4-year college degree _____Some graduate work _____One or more graduate degrees

8. What is your approximate annual household income before taxes? ***(Check your response)***

_____Less than $10,000 _____$10,000 – $24,999 _____$25,000 – $49,999

_____$50,000 – $74,999 _____$75,000 – $99,999 _____$100,000 – $124,999

_____$125,000 – $149,999 _____$150,000 or more

9. Are you retired? ***(Check your response)*** ____Yes ____ No

If you are NOT retired, what is your occupation?
Occupation_____

10. This section asks about which stakeholder group you associate yourself with. *Please circle all that apply.*

A. Government elected official (Federal, state, local/municipal)
B. Government agency official (Federal, state, local/municipal)
C. Regulatory functions at the Federal, state, or local level (e.g., state air quality regulator)
D. Non-regulatory function at the Federal, state, or local level (e.g., state forest service)
E. Environmental conservation at the national, regional, state, or local level
F. Animal welfare group
G. Commodity resource user (e.g., timber, livestock, fee-for-recreation service/facility, outfitters)
H. Non-commodity resource user (e.g., motorized and non-motorized recreationist, hunters, anglers)
I. Utilities (e.g., water provider, electrical transmission, natural gas transmission)
J. Contracted operators conducting any type of forest work
K. Business owner related to or dependent on national forest activities
L. Business owner not related to or dependent on national forest activities
M. Other non-governmental organization (NGO) or community activist (e.g., youth, social justice, or "buy local")
N. Other (*please describe*): _____

11. You have helped us understand why the local national forest is important to you using our list in Part I. Now we would appreciate it if you took a moment to help us understand why the national forest is important to you in your own words.

12. Is there anything else you would like to tell us about the local national forest and what you would like to see happen regarding the mountain pine beetle infestation?

13. In general, how do you think the USFS does in managing the local national forest? Please be specific. We would appreciate any comments.

Please mail the survey and map in the self-addressed, pre-paid envelope back to us. Your time and effort will help with the development of management decisions related to the mountain pine beetle. Thank you very much!