Exploring the Factors that Characterize the Decision Process for the Use of Prescribed Fire in South Carolina

THESIS

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Abstract

The decision to use prescribed fire for the management of forests is a complex and uncertain process. The interplay of the risks and benefits from prescribed fires creates a high degree of uncertainty in outcomes that can lead to the use of various decision-heuristics, or mental shortcuts, for decision-making. A variety of factors can affect a manager's decision to use fire, and may include both cognitive factors internal to the decision maker (e.g. risk-aversion, affect, and availability), and factors that provide guidelines or expectations for behaviors (e.g. existing legislation, management plans, and social influences). Substantial research has examined the cognitive factors that affect human decision-making, but research is limited on factors influencing natural resource decision-making, especially for the use of prescribed fire. This project addresses the gap by providing data which illustrate the influential factors when making decisions about prescribed fire. Semi-structured interviews were completed with fire, smoke, and air quality experts, private burn consultants, and landowners who work in areas adjacent to the Francis-Marion and Sumter National Forests in South Carolina. The study identified the role of risk and uncertainty, and WUI expansion as the most important influences on the decision to use prescribed fire. These were followed by smoke regulations and restoration of the longleaf pine ecosystem as other major factors. The paper concludes with implications from this project for fire and smoke management in the region.

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Chapter 1: Introduction

Large wildfires in the United States have increased in frequency and intensity over the past decade (Toman et al., 2011). As the wildland-urban interface (WUI) increases in size and population density, it creates a growing challenge for land management due to the potential threat from wildfires to human life, welfare, property, and assets (Haines et al., 2008; Toman et al., 2011). The wildland–urban interface (WUI) is the area where houses meet or intermingle with undeveloped wildland vegetation (Radeloff et al., 2005). In response, there has been an increased attempt to proactively manage vegetation to reduce the likelihood of catastrophic wildland fires by using approaches such as prescribed fire, mechanical thinning, and defensible space. While numerous studies examine the use of defensible space and mechanical thinning (e.g. Abrams & Lowe, 2005; Bright & Burtz, 2006a; 2006b; Bright & Newman, 2006), relatively little work has examined the factors that influence the decision by managers to use prescribed fire treatments (exceptions include, Cohan, Haas, Radloff, & Yancik, 1984; Bright & Manfredo, 1995; Zaksek & Arvai, 2004; Wilson et al., 2009). This thesis contributes to understanding the factors that influence the decision to use prescribed fire for land management in South Carolina.

Wade and Lunsford (1989) define prescribed fire as "fire applied in a knowledgeable manner to forest fuels on a specific land area under selected weather conditions to accomplish predetermined, well-defined management objectives" (p.2). Prescribed fire is often used to restore fire adapted ecosystems, and biological information suggests a range of potential positive outcomes from its use including

improvement of land conditions, wildlife habitat maintenance, and disease control (Fernandes & Botelho, 2003). It may also be used to reduce high fuel loads that have accumulated in some U.S. forests following years of fire suppression and, thus contributes to decrease the risk of potentially catastrophic wildfires in the future (Fernandes & Botelho, 2003).

Roughly 89% of the WUI is privately owned land with over one-third of the WUI houses concentrated in the southeastern United States (Radeloff et al., 2005; Theobald & Romme, 2007). Expansion of residential areas in the WUI can influence future management decisions to use fire (Theobald & Romme, 2007), as public perceptions have the ability to influence the use of fire as a management tool (e.g., Weisshaupt et al., 2005; McCaffrey, 2006). The intermixing of human and environmental factors in the WUI can also create a higher risk to public safety from the use of fire. Thus, this project explores the decision-making process for the use of prescribed fire in South Carolina due to the particularly widespread concentration of the WUI in the southeastern U.S.

1.1 Longleaf pine ecosystems and the use of prescribed fire

Longleaf pine ecosystems are considered among the most endangered in the U.S., and in recent decades, preservation and restoration of the longleaf pine ecosystems has become a top conservation priority in the southeastern United States (Knott, 2001). In response, various partnerships such as the Longleaf Alliance and America's Longleaf have been formed to restore longleaf pine forests. Longleaf pine ecosystems covered

over 90 million acres across most of the southeast in pre-settlement era, but today approximately 3 million acres remain (an almost 98% reduction) (Frost, 1993; Kush & Varner, 2009).

Longleaf pine forests provide habitat for a variety of plant and wildlife species including the Red-Cockaded Woodpecker, protected under the Endangered Species Act (Frost, 1993; Knott, 2001). These systems require the regular occurrence of fire to reduce competition from fast growing, but fire susceptible hardwoods and shrubs common to the region (Wahlenberg, 1946; Frost, 1993; Kush & Varner, 2009). The longleaf pines' thick bark, structure, and fire-resistant seedlings allow it to survive regular fires that other pines and hardwoods may not. Additionally, young longleaf pine cannot survive the invasions and deep shade provided by the hardwood and shrub species that can emerge within 3 to 4 years of fire exclusion. Thus, the restoration and preservation of the longleaf pine ecosystem is closely connected to the decision of managers to implement prescribed burn programs to maintain the necessary fire cycle that controls competition, and prepares mineral seedbeds (Knott, 2001).

1.2. An overview of the decision making process

Despite the various ecological benefits, the use of prescribed fire is subject to a variety of contextual factors such as regulatory frameworks (e.g. ESA and Clean Air Act), social pressures, constraints of urban expansion, economic factors, and legal liability for smoke emissions and escaped fires (Haines et al., 2001). For example, the Endangered Species Act (ESA) influences land management decisions by limiting

managers to those options that do not harm listed species, even if the harm is minimal or short term as compared to the benefits of the technique (Noss, O'Connell, & Murphy, 1997). Similarly, population growth in the WUI increases the smoke sensitive areas and can constrain the use of fire due to stricter smoke management regulations. However, not all factors pose constraints on decisions: landowners are motivated to use prescribed fire for timber stand management to reduce competing hardwoods in pine plantations of timber, while allowing for the growth of desired longleaf pine, and reducing vegetation loads that could increase the probability of wildfires. However, a small number of prior studies also show that beyond contextual factors, the decision to use prescribed fire is affected by cognitive factors internal to the decision maker such as risk-aversion, message framing, status quo, affect and availability biases (Maguire & Albright, 2005, Wilson & Arvai, 2009).

Traditionally, the Expected Utility Theory (EUT) has been the dominant theory in the field of psychology for the analysis of individual decision-making. The EUT states that the decision-maker chooses between risky or uncertain outcomes by comparing the expected utility values between alternatives (Mongin, 1997). Decision makers are expected to behave in a rational manner to maximize their utility, which is defined as the relative satisfaction or desirability of a good or service. However, the influence of several other variables including societal norms and personal experience, among others, can limit the ability to engage in a purely rational decision-making process. This is described in the concept of "bounded rationality" that states that although individuals are inherently rational decision-makers, information-processing

limits to memory, perception, and judgment bound their abilities to evaluate complex choices and act consistently over time (Simon, 1990). Thus, when faced with complex choices under uncertain circumstances in land management, decision-makers are unlikely to stick to a purely rational process and tend to adopt various short-cuts or heuristics, explained under prospect theory (Kleindorfer et al., 1999).

Prospect theory, posed by Kahneman and Tversky (1979), focuses on making decisions under risk (defined as the probability of occurrence and the magnitude of negative consequences) or uncertainty (where there is less than complete knowledge about potential outcomes), and assigns value to gains and losses, rather than to final assets (net utility) as under EUT. The theory states that individuals tend to make decisions based on the potential value of losses/gains, rather than the final outcome, by using various heuristics and biases. Individuals also have a tendency to value alternatives that are perceived to have definite outcomes higher relative to those that have merely probable outcomes (Kahneman & Tversky, 1979). In other words, even if an alternative might have a higher return, such as improved ecological benefits from prescribed fire use in the long run, but it is probable or uncertain in its outcome, it might be undervalued when compared to an option that is perceived to be certain, such as mechanical thinning despite providing fewer ecological benefits (Wilson et al., 2011).

Under prospect theory, individuals also have a tendency to be risk-averse in choices involving gains and risk-seeking in choices involving losses (Tversky & Kahneman, 1981), where an individual's perceptions of risk are based purely on how the decision problem was framed – as a gain or as a loss. Thus, beyond a tendency to

value ‘certain’ outcomes over probable ones, individuals also have a tendency to make decisions based upon the chosen ‘frame’ of the message or decision problem.

1.3 Objective and Thesis Organization

The purpose of this research was to explore the factors that characterize the decision making process for the use of prescribed fire in South Carolina. This study aimed to identify the various contextual and cognitive factors that influence the decision process for the use of prescribed fire in forest management in the areas adjacent to the Francis-Marion and Sumter National Forests in South Carolina. Drawing on prior research we examined applicable contextual factors including regulatory frameworks (Endangered Species Act and smoke management guidelines), and social influences; as well as the cognitive factors including the role of risk and uncertainty, message frames, and decision-heuristics of affect, availability and status quo that influence decision-making. An understanding of these factors will provide an important contribution to the broader discussion on the natural resource decision-making process, and the role of these factors on achieving management objectives for the use of prescribed fire.

The thesis is organized in six chapters. Following this introduction, the subsequent chapter reviews the existing literature in the field of decision making for prescribed fire management. Then, the methods used to conduct this research are described. The fourth chapter presents the main findings of the study organized according to the various contextual and cognitive factors that influence the decision-making process for burn managers in the region. The discussion section describes key

lessons provided by this project in relation to broader literature. The thesis then concludes by identifying implications from this project for fire and smoke management.

Chapter 2: Literature Review

Natural resource management has traditionally used information from the biological and physical sciences to guide decision-making for fire and fuels management. However, biological and physical science in itself is not enough to make complex decisions relating to the intermixing of environmental and human factors in the wildland-urban interface (WUI) (Mills & Clark, 2001). The complex interplay of the risks (e.g., escape) and benefits (e.g., forest health) from prescribed fires creates a high degree of uncertainty in outcomes that can lead to the use of various decision-heuristics, or mental shortcuts, for decision-making (Slovic, 1995; Tversky & Kahneman, 1974). Thus, various contextual and cognitive factors need to be considered to understand the decision making process for fire and fuels management.

While numerous studies exist on an individual's decision-making processes (e.g. Tversky & Kahneman, 1979; Slovic, 1997 etc.), there is relatively little research examining the factors that influence the decision by managers to use prescribed fire treatments (exceptions include Bright & Manfredo, 1995; Wilson et al., 2009; Zaksek & Arvai, 2004; Cohan, et al., 1984; Maguire & Albright, 2005). This chapter is a review of prior literature that is relevant to this study. We begin with a discussion of contextual factors (regulations and social concerns), and then examine prior literature on cognitive factors such as risk-aversion and various decision heuristics and biases that influence natural resource managers.

2.1 Contextual factors influencing decision making for the use of prescribed fire

A variety of contextual factors can constrain or motivate natural resource managers to use prescribed fire as a management tool. Existing research identifies public opinion and safety, WUI expansion, and smoke regulations as important influences on the decision to use prescribed fire (e.g. Cortner et al., 1990; Haines et al., 2001; Reibau & Fox, 2001). Given their importance in prior research, we included these factors in our analysis of decision-making in South Carolina. Given the status of the Red Cockaded Woodpecker, interviews also examined the influence of the Endangered Species Act.

2.1.1. Regulatory Framework

2.1.1.1. Endangered Species Act and the Red-Cockaded Woodpecker

The purpose of the Endangered Species Act of 1973 (ESA) is to conserve the ecosystems upon which endangered and threatened species depend through habitat protection and restoration (Noss et al., 1997). The ESA mandates that all species listed as threatened or endangered are 'to be protected from all harm', which includes direct (e.g. hunting) and indirect harm (e.g. adverse modification of habitat) (Noss et al., 1997; Lueck & Michael, 2000; US FWS, 2003). For federal management actions, the ESA requires that government agencies ensure their actions neither jeopardize the continued existence of protected species nor result in the destruction or adverse modification of the habitat essential to the species' conservation (Lueck & Michael, 2000). On private land, beyond the broad prohibition of actions that "harm" endangered species and

prevents land-owners from harvesting the species' foraging and nesting habitat, private landowners are not required to participate in active conservation of the species under the ESA (Lueck & Michael, 2000; US FWS, 2003). However, through voluntary programs such as Safe Harbor agreements, private landowners may agree to actively manage their properties to provide habitat for protected species with assurances of no additional land-use restrictions or required actions to recover the listed species (US FWS, 2003). For all listed species, federal government agencies are mandated to develop a recovery plan with the defined objective of recovering the population to the point that it can be removed from the protections of the ESA.

Within our study region, the Red-Cockaded Woodpecker (RCW) is listed as endangered under the ESA. The RCW is a territorial, non-migratory species that requires mature pine forests, preferably longleaf pine, with open woodlands for nesting, foraging, and roosting (US FWS, 2011; US FWS, 2003). Loss of open woodlands from encroachment of hardwoods that result from fire suppression has been noted as a leading cause for severe population decline (US FWS, 2003). The RCW Recovery Plan developed by the U.S. Fish and Wildlife Service (US FWS) recommends actions that encourage the growth of longleaf pines, protection of forest corridors, and the restoration of fire to its natural frequency, intensity, and seasonality to maintain desired habitat conditions (US FWS, 2010). Natural frequency of fire in the longleaf pine ecosystem, and other southern pine ecosystems, is low to moderate intensity fire every 3-4 years (Frost, 1993). The use of mechanical and chemical treatments can meet some of the RCW habitat needs by removing mid-story vegetation; however, maintaining

suitable habitat in the long run is dependent on the use of prescribed fire for maintenance of appropriate herbaceous groundcover, and to minimize disturbance to soils, pine tree roots, and desired native species (USFWS, 2003). From a cost perspective, prescribed burns are a highly cost-effective means of controlling hardwood and shrub encroachment (Frost, 1993).

2.1.1.2. Smoke Regulations

Any type of vegetative debris burns conducted for forestry, agriculture, and wildlife purposes in the state of South Carolina are subject to air quality regulations under the Clean Air Act (CAA) of 1970 and the Smoke Management Guidelines published by the South Carolina Forestry Commission (SCFC).

The Clean Air Act of 1970 authorizes the U.S. Environmental Protection Agency (EPA) to establish National Ambient Air Quality Standards (NAAQS) in order to protect public health and to regulate emissions of hazardous air pollutants to protect and improve national air quality and the stratospheric ozone layer (Bureau of Air Quality, 2009). The EPA does not directly regulate the use of fire and only enforces the requirements of the CAA (EPA, 1998). This allows states to have flexibility in regulating emissions from managers' use of fire as long as they adequately protect air quality and maintain the NAAQS. In South Carolina, the state Department of Health and Environmental Control (DHEC) is responsible for the implementation, maintenance, and enforcement of the NAAQS (BAQ, 2009). Forest prescribed burning was granted an exemption beginning in 1970 because it was not included in the CAA as

a major source of pollution (BAQ, 2009). However, as concerns about the effects of smoke emissions from prescribed burns increased, the SCFC formulated the Smoke Management Guidelines in 1981. The resulting guidelines for vegetative burns are more stringent than those required by the CAA, and can be restrictive to the use of prescribed fire, especially near smoke sensitive areas such as neighborhoods or busy transportation corridors (Kush & Varner, 2009).

The SCFC requires all burn managers to call the Forestry Commission Dispatch Center on the scheduled day of burn to obtain a permit prior to carrying out their burn plan. To receive this permit, burn managers must provide their prescribed burn plan that includes information on fuel loading tonnage, acreage to be burned, objectives for the burn, nearest downwind smoke sensitive area, and ideal weather for the burn among other information. The SCFC considers this information in light of current and forecast weather conditions and the other scheduled burns within the region before determining whether a permit should be granted. The primary objective of this process is to reduce the particulate matter that is released into smoke sensitive areas by regulating the amount of burning that can occur depending on the potential for smoke dispersal. Based on weather conditions the SCFC designates the amount of permissible burning that may occur within a particular geographic region. These designations include (SCFC, 2006):

- Category days (1 through 5) – indicate how well smoke will disperse based on the weather forecast for a given day based on ventilation rates (wind speed x mixing height); category 1 has the worst dispersion rate for smoke

emissions, and category 5 has the best smoke dispersion with high winds and mixing rates.

- Fuel loading - indicates average tonnage per acre for most types of vegetative fuels depending on closest smoke sensitive area and category day.
- Smoke Sensitive Areas - places where smoke might be harmful or offensive (i.e. highways, airports, farms or neighbors with health problems).

2.1.2. Social Influences

Fire managers need to understand how various social factors can influence the managerial decision making process regarding the use of prescribed fire (Manfredo et al., 1990; Mercer & Prestemon, 2005; Winter et al., 2006). Substantial prior literature (e.g. Cortner et al., 1990; Haines et al., 2001) indicates that social factors including public acceptance of prescribed fire use, resulting smoke emissions, and increasing human populations in the WUI can influence the abilities of managers to implement prescribed burn programs. Each of these topics is discussed in greater detail below.

Earlier research in western regions suggests that fire managers have a tendency to avoid using fire when faced with a potential threat to human safety (Cortner et al., 1990). Managers are known to be sensitive to public perceptions and possible community concerns with smoke from prescribed fire due to the possibility of an issue escalating into a national issue (Cortner et al., 1990). Even though citizen acceptance and perceptions of prescribed fire use have increased over the past few decades (e.g., Loomis et al., 2001; Shindler & Toman, 2003; Toman et al., 2011), in some locations, a

substantial number of study participants have also expressed concerns regarding the potential for the fire to escape and impacts from smoke emissions (Shindler et al., 2009).

Management use of prescribed fire is becoming increasingly difficult due to population growth near natural landscapes which increases the number of residents potentially exposed to negative impacts from wildland fires (thus, increasing pressure for fuels reduction activities prior to a fire event) while also increasing the number and proximity of various smoke-sensitive areas (such as schools and major roadways) (Miller & Wade, 2003; USDA & DOI et al., 2004). Research has found that WUI expansion, public opinion, legal liability, and smoke management laws are among the top barriers to conduct prescribed burns in the southern United States (Haines et al., 2001). However, studies also show that in regions where prescribed fire is an established practice, public acceptance among WUI residents tends to be high (Winter et al., 2006). Additionally, positive attitudes towards fire use are more widespread where the public is familiar with successful fuels management over the long term in the region (Winter et al., 2006).

2.2. Cognitive factors influencing natural resource decision-making

A decision can be thought of as a choice between two or more alternative measures. A rational decision making process under the expected utility theory includes defining the situation at hand, collecting information on alternatives, selecting the most

'rational' (utility maximizing) alternative, and finally implementing the chosen alternative (McDermott, 2006). For example, a rational decision-making process to use prescribed fire might include the objective estimation of potential outcomes by assigning values to expected benefits from a successful prescribed fire compared to continuation of the status quo, versus the likelihood and expected magnitude of negative impacts an escaped fire (one that burns outside of management prescription) could potentially cause (Maguire & Albright, 2005). However, prescribed fire managers have to consider multiple factors when deciding whether to use prescribed fire. As they attempt to merge biophysical, social, and economic objectives, this decision can become complex, and not easily expressed in terms of 'maximum utility.' The decision to use prescribed fire gets even more complex due to the uncertainty surrounding the future outcomes (Schmoldt & Rauscher, 1996), and research suggests that managers tend to employ decision heuristics, or mental shortcuts, to make these decisions simpler due to the uncertainty about outcomes, and multiple conflicting objectives (Camerer & Kunreuther, 1989; Tversky & Kahneman, 1974).

In the following subsections, we explore the role of risk and uncertainty, message framing, and the decision-heuristics of affect, availability, and status quo that may influence management decisions for the use of prescribed fire.

2.2.1. Risk and Uncertainty

Risk is the potential for realization of unwanted negative consequences of an event, and is dependant upon the probability of occurrence and the magnitude of the

consequences (Gough, 1988). Perceptions of risk among the general public tend to reflect concerns about controllability, voluntariness, and the degree to which the risk is known (Slovic & Fischoff, 1982). While less research examines experts, such as fire managers, the limited studies that have been completed suggest that experts' judgments of risk may also be influenced by many of the same biases as those of the general public, particularly when experts are forced to go beyond available information and rely on intuition (Kahneman et al., 1982; Wilson et al., 2011).

Uncertainty in the decision-making process arises when there is no definite knowledge about the consequences of the decision (Tversky & Fox, 1995) i.e. multiple possible outcomes with unknown probabilities of occurrences. Prescribed fire decisions tend to have uncertain outcomes due to intermixing of factors such as weather, topography, and fire behavior that are difficult to predict with certainty (Cohan et al., 1984). For example, Figure 1 shows the possible outcomes from the use of prescribed fire - controlled and escaped, where each outcome can have a desired (ok) or uncertain (?) effect on the objectives of timber management and longleaf pine habitat restoration.

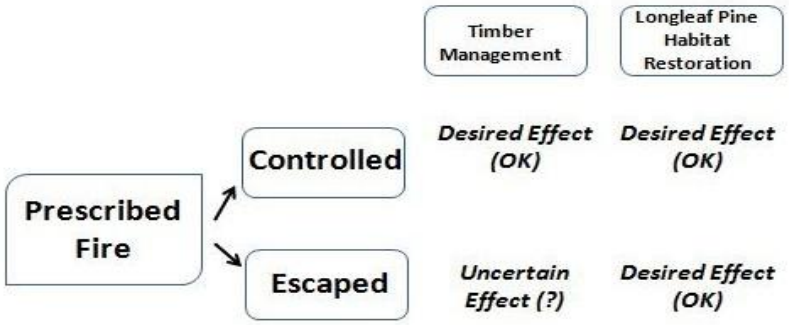

Figure 1: Uncertainty in prescribed fire decision outcomes (*adapted from Maguire & Albright, 2005).*

Risk and uncertainty are inevitable in the management of biophysical and socio-economic systems (Stankey et al., 2003), and they are an integral part of all decision-making (Gough, 1988). Risk and uncertainty can arise due to the environment in which the decision is made, or they may be connected to the nature of the decisions themselves (Gough, 1988; Slovic & Fischoff, 1982), such as the inherent risk of escape and uncertainty about outcomes associated with prescribed fire use. When a decision, such as the use of prescribed fire, is perceived as high risk with uncertain outcomes, managers tend to be risk-averse in their decision to use fire (Maguire & Albright, 2005; Stankey et al., 2003) due to agency safety concerns, and potential risk of personal liability in the event of an escape (Canton-Thompson et al., 2008). Managers also tend to view fire damage to habitat and property resulting from a naturally ignited wildland fire as less serious than the same damage arising from an escaped prescribed fire (Maguire & Albright, 2005), making them more risk-averse towards its use. In a recent study, managers indicated the potential risks from the use of fire, and uncertainty

surrounding its outcomes are constraining to the use of fire as a management tool (Wilson et al., 2009).

While substantial research has explored the public perceptions of risk, particularily relating to wildfire risk (e.g. Arvai et al., 2006; Daniel, 2007 etc.), relatively little research has examined the managerial perceptions of risk resulting from the use of prescribed fire (exceptions include, Cohan et al., 1984; Bright & Manfredo, 1995; Zaksek & Arvai, 2004; Wilson et al., 2009). This research tries to fill the gap by examining the role of risk and uncertainty in the mangers' decision to use prescribed fire as a forest management technique.

2.2.2. Message Framing

Decision-makers tend to view decisions involving losses or gains with different levels of risk, and tend to be risk-averse towards potential gains and risk-acceptant towards losses (Kahneman & Tversky, 1979). In a leading example from Kahneman and Tversky (1979), two different groups of students were asked to choose between two programs each to combat the outbreak of an unusual Asian disease, which was expected to kill 600 people. 72% of the respondents in group one chose the 'certain' program where 200 people would be saved, over the program that had 1/3rd probability that 600 would be saved, even though the two outcomes were equal; when it came to choosing between losses in group two, the majority (78%) chose the program with 1/3rd probability that no one would die over the certain program that 400 people would die. The difference in how participants perceived risk in the example was based purely on

how the decision problem was framed – as a gain or loss (Wilson et al., 2011; Kahneman & Tversky, 1979).

A '*framing*' effect is said to occur when a certain type of communication / information changes how an individual weights a particular piece of information (Tversky & Kahneman, 1981). The manner in which a decision is 'framed' or formulated has a strong effect on the decision-makers preferences and the level of acceptance (Tversky & Kahneman, 1981: Kleindorfer et al., 1999). Research suggests that when a decision is framed in terms of returning to an earlier better status i.e., restoration, it is evaluated more favorably than an otherwise identical decision that is framed around the current status i.e., maintenance (Gregory, Lichtenstein, & MacGregor, 1993). For example, Wilson et al. (2009) found that management objectives with a restoration emphasis took precedence over objectives of maintaining forest conditions to provide forest products. Additionally, framing a fuel management plan to restore "lost" forest health rather than to maintain for timber increased the willingness of individuals to support options that might be higher in risk or pose a risk of failure (Wilson, Ascher, & Toman, In Press).

2.2.3. Decision Heuristics and Biases- Affect, Availability, and Status Quo

Affect is defined as a person's good or bad, positive or negative feeling about objects and events (Leiserowitz, 2006), and it allows people to navigate quickly and efficiently through complex and uncertain situations by drawing on the feelings associated with particular events (Alhakami & Slovic, 1994). These feelings have been

shown to influence the decision process (Slovic et al., 2002), and are often based on prior experiences and thoughts perceived as relevant to the decision. Research shows that complex and uncertain decisions (e.g. use of prescribed fire) that require extensive information processing are likely to be influenced by affect (George & Jones, 2001), and the use of an affect heuristics has been shown to influence the decision-making behavior among managers (Alhakami & Slovic, 1994; Slovic, 1995). Affect can also influence public acceptance of management-ignited prescribed fire, and research in other regions has identified the potential long-term influence on the lack of support for its use from an escaped prescribed fire (e.g., Winter et al. 2002).

The *availability heuristic* can also lead to decision-making biases. Tversky and Kahneman (1974) define the availability bias as a 'rule of thumb' that individuals use to determine the frequency or probability of an event based on the ease with which the occurrence is brought to mind. Events that are more recent, vivid, or are personally experienced will influence an individual's estimate of its likely occurrence in the future (Tversky & Kahneman, 1974). Thus, the vivid memories caused by an escaped prescribed burn may influence perceptions of the likelihood of escape from future events, despite statistics indicating that nearly all prescribed fires are maintained within prescription (Winter & Fried, 2000).

Affect and availability tend to complement one another in determining the risk perception of a hazard such as fire. Vivid information is often more available (easily recalled), and the more available the event, the greater is the perception of risk (e.g. likelihood and consequences of escape), that may in turn influence the acceptance or

rejection of the technique (e.g., prescribed burning) (Plous, 1993). Similarly, in the opposite direction, managers have a tendency to underestimate the likelihood of adverse events and exaggerate the likelihood of favorable events that can lead to risk-taking behavior (e.g., use of prescribed fire) (Weinstein, 1980; Maguire & Albright, 2005). Furthermore, it has been observed that sometimes managers tend to ignore risks with probabilities below a certain threshold (Slovic et al., 1977) that could explain risk-taking behavior for the use of prescribed fire where the probability of an escape is low.

Research also shows that personal experience with certain events such as an escaped burn or successful use of fire tends to bias future judgments related to the event (Slovic & Fischoff, 1982). Thus, personal experience becomes a determinant of behavior as the nature of experience, positive or negative, can create strong affect, and the amount or frequency of the experience can make the decision more available (Slovic & Fischoff, 1982). As a result, managers may rely on prior vivid experiences with prescribed fire use to predict the outcomes of future fire use. Research shows that past catastrophic escaped fires had a tendency to sharply reduce the future use of prescribed fire due to the high negative affect associated with the event, and increased perceived probability of escape (e.g. Maguire & Albright, 2005).

To reduce the high risk and uncertainty associated with a decision, managers may elect to continue with the status quo. The *status quo bias* is the decision to stick to the already existing practice rather than to take the risk to switch to a new technique as continuing with the status quo or traditional management is seen as less ‘risky’. Samuelson & Zeckhauser (1988) conducted a serious of experiments on decision-

making where it was found that individuals disproportionately stuck with the status quo, even if it could be demonstrated as suboptimal. Decision-makers feel less responsible for negative outcomes resulting from a lack of action, i.e., staying with the status quo, rather than for outcomes resulting from purposeful action (Camerer & Kunreuther, 1989). Research shows that managers have a tendency to continue with the status quo techniques of the region and agency when faced with complex decisions and multiple options for forest management (Maguire & Albright, 2005). Furthermore, future gains to habitat and ecosystem health tend to be overshadowed by the potential of huge losses from escaped prescribed fire (Magurie & Albright, 2005).

Chapter 3: Methods

A case study design was used to conduct an in-depth analysis of the factors that influence the decision making process for the use of prescribed fire in South Carolina (Yin, 2009). A case study is an empirical inquiry investigating a 'phenomenon' within its real-life context (Yin, 2009). The research team conducted semi-structured interviews to enable identification and a rich understanding of the factors that affect prescribed fire management decisions in the region adjacent to the Francis-Marion and Sumter National Forests in South Carolina.

3.1. Francis-Marion and Sumter National Forest Region

A critical-case protocol was used to identify the Francis-Marion and Sumter National Forests in South Carolina as the appropriate research site for this project. According to Robson (2002) and Yin (2009), a critical case is not selected at random, but 'purposively' chosen due to its unique properties to provide a rich and deep understanding of the research questions, and to generate new theories, and/or falsify or strengthen already existing theories. Criteria used to select the site for this research included: a previously under-studied region in human dimensions of prescribed fire research, communities in proximity of large national forests providing a substantial wildland-urban interface (WUI), history of wildfire events, and regular use of prescribed fire in the region. Based on these criteria, the Francis-Marion and Sumter

National Forest region was selected to explore management decision-making by prescribed burn managers.

The Francis-Marion National Forest consists of over 259,000 acres in coastal South Carolina, and on average, 40,000 acres are burned by prescription annually to meet a variety of resource management objectives (USDA Forest Service, 2012). The Francis-Marion spreads across Charleston and Berkeley counties with numerous private in-holdings and fragmented ownership along the forest perimeter. The Forest offers a variety of recreational opportunities for the public, and includes an extremely diverse ecosystem, ranging from pine stands to swamps and marshland (USDA Forest Service, 2012). In 1989, Hurricane Hugo passed through the area resulting in a blow down event that affected approximately one third of the forest and resulted in a high fire threat. In response, forest managers engaged in extensive efforts to reduce the resulting fuel loads, including substantial use of manager-ignited prescribed burns (USDA Forest Service, 2012). The Sumter National Forest includes three ranger districts comprising nearly 371,000 acres, and offers a variety of recreational opportunities (USDA Forest Service, 2012). The three ranger districts of the Forest are located across multiple counties such as Oconee, Newberry, Edgefield, Laurens, and Saluda counties and have a complex, broken land ownership pattern, where forest land is intermingled with private property (USDA Forest Service Southern Region, 2005). The USDA Forest Service (USFS) manages both of these National Forests for multiple uses including timber production, wildlife habitat, and outdoor recreation (USDA Forest Service, 2012).

The Francis-Marion and Sumter National Forests are considered ‘urban forests’, defined as a forest within an hour’s driving distance of a million or more people and/or major metropolitan areas (USDA Forest Service Southern Region, 2005). The Francis-Marion National Forest is located in proximity to several rural communities, as well as two major metropolitan areas: Myrtle Beach (30 miles north) and Charleston (40 miles south). The Sumter National Forest is in proximity of the large metropolitan city of Columbia and various other small towns. Fire protection for non-structural fires in South Carolina is shared between the South Carolina Forestry Commission (on private lands) and the USDA Forest Service (on USFS lands), with assistance provided by the county, municipal, and volunteer fire departments (SCFC, 2012; USDA Forest Service, 2012).

Prescribed fire in this region had been originally used as a silvicultural tool to manage for timber. In recent decades, the USDA Forest Service (USFS) emphasis on restoring longleaf pine forests and endangered species habitat has increased the use of prescribed fire in the southeast (Haines et al., 2001). Many of the surrounding state forests, wildlife refuges, military bases, and private landowners also use prescribed fire for restoration of longleaf pine habitat, wildlife habitat, and fuels and wildfire reduction benefits.

Recent years have seen increased demand for housing and development near the Francis-Marion and Sumter National Forests as the land is becoming increasingly desirable for resulting amenities (USDA Forest Service Southern Region, 2005). There is concern among forest managers that management activities, such as prescribed

burning, might become more difficult in coming years because of opposition from this increasing human population (USDA Forest Service Southern Region, 2005).

3.2. Study Design

The research team conducted semi-structured interviews with twenty-eight participants - fire, smoke, and air quality experts, private burn consultants, and landowners, who work in areas adjacent to the Francis-Marion and Sumter National Forests. The participants were located in Charleston, Richland, Lexington, Georgetown, Dorchester, Beaufort, Aiken and Berkeley Counties (Figure 2). Of these, nine interviews were conducted in-person, with the remaining completed by phone. The interviews varied in length from 30 minutes to 60 minutes.

A standard interview instrument (Appendix A) was prepared and modified to address the particular context for each participant. The interview questions were developed using findings from prior literature on natural resource decision-making as a guideline, while keeping them flexible enough to gather an in-depth knowledge on the factors influencing decision-making. The open ended interviews provided a rich understanding of the factors that influence the managerial decision to use fire, possible concerns with the use of prescribed fire, and the various obstacles and opportunities in the region for future fire and smoke management.

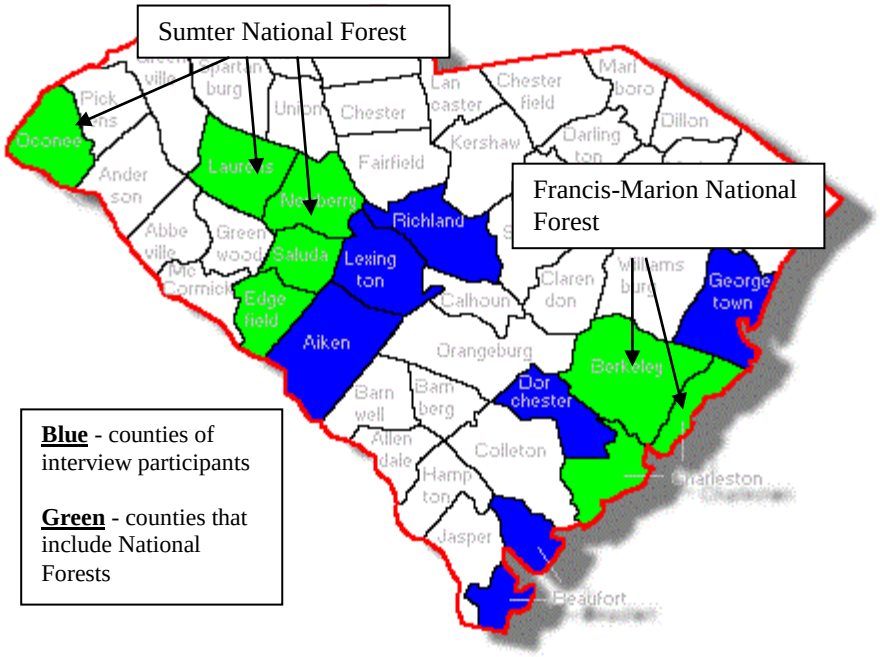

Figure 2: Map displaying counties where interviews were completed

Interviews were conducted until saturation was reached. Data saturation is reached when all subsequent interviews conducted provide repetitive information, without adding any new knowledge to the existing understanding of the factors (Morgan, 2002). With participant consent, interviews were recorded and transcribed. In the few cases when participants did not agree to being recorded, the team relied solely on note taking. Follow up e-mail and phone conversations were conducted to clarify responses when necessary.

Study participants were identified from publicly-available records, such as agency websites and the directory of county officials, and through snowball sampling. Snowball sampling is the identification of possible information-rich individuals by

current research participants (Patton, 1990). Following the interview, all participants were asked to identify additional members of the community, important stakeholders, and agency personnel engaged in fire and smoke management discussions in the region. There was some overlap among the respondents suggested, which provided evidence that the most appropriate individuals were included in the study. Potential participants were contacted through phone and/or email to introduce the study, its intent, and their willingness to participate. A follow-up email with confirmation of time, date, and place was then sent.

Government Agencies (# of participants)	**Non-Government Organizations (# of participants)**	**Private Consultants & Landowners (# of participants)**
US Forest Service (3)	Turkey Federation (1)	Private Burn Consultants (3)
South Carolina Forestry Commission (2)	The Nature Conservancy (1)	Private Landowners (3)
Congaree National Park (1)	Joseph James Research Center (1)	
Bureau of Air Quality (2)	Hitchcock Woods (2)	
Military Bases (3)	Sandhills Wildlife refuge (1)	
US Fish and Wildlife Service (1)	Audubon Society (1)	
SC Department of Natural resources (1)	Nemours Wildlife (1)	
Local County Official (1)		
$N_{Government} = 14$	**$N_{Non\text{-}government} = 8$**	**$N_{Private} = 6$**

Table 1: List of agencies and number of interview participants (n=28)

The interview sample was representative of the individuals with the management of prescribed burns in the region. Interview participants represent a variety of government agencies (14 participants), non-government organizations (8

participants), a local county official (1 participant), independent prescribed burn consultants (3 participants), and private landowners (3 participants) conducting burns on their property (Table 1). Unlike other regions of the U.S., private landowners are actively engaged in conducting prescribed burns in South Carolina.

3.3. Analysis of Data

The qualitative data was analyzed using systematic interpretive coding techniques. Coding is the process of raising the raw data to a conceptual level, and codes are the names given to concepts derived through coding (Strauss & Corbin, 1997). The coding process involves distilling the data, deriving concepts by sorting them, and asking questions about the data to make comparisons with other data segments (Strauss & Corbin, 1997; Charmaz, 2003).

Coding of data was conducted using NVIVO v.9.0 software. Procedures involved developing basic categories of information, development of themes based on these categories, and finally building a narrative to connect the various data segments (Strauss & Corbin, 1997). The coding process helped to narrow the focus and reveal key themes. Each new category or code that emerged within an interview was assigned a new node in the NVIVO hierarchy. The codes for contextual factors were developed based on the influences cited directly by participants as influencing the decision to use prescribed fire, whereas codes for cognitive factors were developed using prospect theory and the various decision-heuristics as a guide. The results below were the final

themes developed through this process that were categorized under the various contextual and cognitive factors. To assess reliability, an independent researcher coded nine of the interviews; coding was consistent between the two coders, and no differences were identified that would affect the results.

Chapter 4: Results

Study participants had extensive experience conducting prescribed burns (varying from 8 to 20 years) and nearly all (over 90%) were also native to South Carolina. Most of the participants were male (90%), a reflection of the traditional gender differences among fire management professionals. The educational level varied from some with a high school degree to those who had completed a graduate degree.

The interviews explored the factors that influence the decision to use prescribed fire as a management tool in South Carolina. These factors include the various contextual and cognitive factors that influence prescribed fire decision-making. Table 2 lists the main themes from the interviews, and the following pages explain these results with supporting information such as interview quotes, and tables. The chapter begins by examining the contextual factors, and then provides results related to the cognitive factors.

Contextual Factors	Cognitive Factors
1. Regulatory Factors a. ESA (for RCW) b. Smoke Regulations i. EPA Clean Air Act ii. SCFC Smoke Guidelines 2. Social Influences a. Public Perceptions/Awareness b. Urban Sprawl c. Public Safety d. Fuels Reduction	1. Risk & Uncertainty - Liability and Public Safety 2. Message Framing 3. Decision Heuristics / Biases a. Status Quo b. Affect c. Availability

Table 2: Factors influencing burn managers' decision making in South Carolina

4.1. Contextual Factors

Interview participants noted the influence of legal and regulatory frameworks, as well as social influences on their decisions. Table 3 lists the factors and the number of participants from the various government agencies, non-government agencies, and private consultants and landowners that mentioned each item. It also shows the overall percentage of respondents who indicated that the factor influenced their decision to use prescribed fire.

Contextual Influences	**# of participants**			**Overall %**
	Govt.	*NGO*	*Pvt.*	
Regulatory Factors				
a. SCFC Smoke Guidelines & Clean Air Act	10	5	6	*78%*
b. ESA (for the RCW)	8	3	2	*48%*
Social Influences				
a. WUI Expansion	10	7	6	*85%*
b. Public Safety	10	6	6	*82%*
c. Fuels Reduction	10	3	4	*63%*
d. Public Perceptions/Awareness				
i. Lack of Awareness	9	6	5	*74%*
ii. Understand trade-off	7	4	6	*63%*
N	***14***	***8***	***6***	***100%***

Table 3: Contextual influences noted by participants (n=28)

4.1.1. Regulatory Factors

Interview participants mentioned the role of regulatory factors in the managerial decision to use prescribed fire in South Carolina, where the Clean Air Act and the South Carolina Forestry Commission (SCFC) Smoke Management Guidelines were cited as being constraining to the use of fire. Over three-fourths of all respondents indicated that

the smoke management guidelines restricted their ability to conduct burns at the frequency and size that they would prefer. Smoke regulations tend to narrow the available days when managers can use prescribed fires (described as a prescription window), and thus limit managers' ability to achieve annual burn targets: "*The burn is not the hard part, it is the smoke guidelines. We have very strict guidelines for smoke dispersion from the state of South Carolina. It's one of the strictest in the country - you got to get the right wind and the right conditions which really hamper what we can burn. But we are doing the best we can*" *– US FWS employee.*

This sentiment was even more pronounced among private burn managers, as they all cited smoke management as a barrier to prescribed fire use. Private consultants and landowners further indicated that these restrictions had become more challenging as human development increased in the WUI: "*For each acre lost to urban sprawl, we lose about one burn day in the prescribed burn calendar" – Private burn consultant.*

However, not all regulatory factors were noted as constraining to use of prescribed fire. Participants indicated the Endangered Species Act (ESA) had a motivational effect on the use of prescribed fire to maintain longleaf pine ecosystems for the Red-Cockaded Woodpecker (RCW) habitat. Just under half of the overall participants (48%) indicated that they used fire to maintain RCW habitat. The ESA was mentioned more often by agency managers than the other participants; more than half of agency managers indicated they burned to promote RCW habitat versus 33% of private burners and 37% of non-government organizations: *"The RCW is a very important species in this forest because it's an endangered species, and its needs for diet and reproductive habitat are fire adaptive. They cannot tolerate a heavy mid-story which results from fire exclusion.*

They need real open understory as a result of the frequent burning we do for the woodpecker clusters" – USFS Employee.

The agency managers who did not use fire to develop RCW habitat indicated that it was due to the lack of RCW within the areas they manage rather than concern about negative impacts from the use of prescribed fire on RCW habitat. However, three-fourths (85%) of the agency managers regularly used prescribed fire for longleaf pine restoration, which is the preferred habitat for the RCW. Indeed, some agency managers who do not currently have RCW populations on their properties (National Park Service, military base) indicated that by restoring longleaf pine, they hoped for the RCW to return to the property: *"Hurricane Hugo pretty much devastated our mature pine forest and the RCW population declined to nothing. We do not have any right now but we hope they return in future. So we continue to manage the forest in a way that we hope the woodpecker will return at some point" – Naval Joint Base, Charleston.*

4.1.2. Social influences

Social factors were cited as having a major influence on the current use of fire, and were also mentioned as creating obstacles for future burn programs. The most frequently cited social factors constraining the use of fire were the wildland-urban interface (WUI) expansion (85%) and public safety (82%).

WUI expansion increases the number and proximity of smoke sensitive areas, reducing the number of burn days available to conduct burns under the smoke management guidelines: *"Urban sprawl is largely becoming the main issue to not being able to burn because of smoke sensitive areas and developments and roads and things like that*

popping up all over the place. Areas that need to be burned or should be burned are starting to be lost because of smoke sensitive areas" – Private burn consultant.

Most participants (82%) also noted that prescribed fire use was constrained by potential impacts to public safety. Of primary concern from these quotes was not the risk of escape, but rather the possibility of smoke intrusions on the highway and major roadways. Smoke from prescribed burns can result in reduced visibility that can cause traffic accidents, and potentially human fatalities. As one participant indicated: "*I just want to emphasize that the main issue is trying to balance public safety and looking at smoke sensitive areas while we try to do our job to burn" – Nemours wildlife.*

On the other hand, several participants indicated social factors may also serve as a motivation to increase the use of prescribed fires. Specifically, just under two-thirds (63%) indicated that the increased human development encouraged the use of prescribed fire for fuels reduction to decrease the potential of future catastrophic wildfires in the region. These participants recognized this increased population may create a management conundrum due to an increase in number and proximity of smoke sensitive areas. Ultimately, they indicated the actual use of fire for fuels management was dependent on public perceptions and acceptance of prescribed fire. A private landowner in the region noticed that "*agency managers seem to be very limited and influenced by public perceptions."*

There was unanimous (100%) agreement among all participants that, traditionally, residents in rural areas generally understood the benefits and supported the use of prescribed fire as it was part of cultural history in the region. However, managers expressed doubts as to whether such attitudes would continue with the recent WUI

expansion. Several indicated concerns that the newly arriving residents may be less likely to understand the ecological benefits provided by prescribed fires and have greater concerns for its use. As one participant described this: "*Many people do not understand prescribed fire. It is because we have a rapidly urbanizing society that is disconnected from the natural world. But when you go to the rural areas people tend to know burning and recognize that with forest management or wildlife management and you don't get those complaints" – Researcher, Joseph James Research Center.*

Along these lines, most (74%) of the respondents noted that urban residents, who were viewed as driving the majority of population growth in the WUI were less supportive of prescribed fire use. Accordingly, managers were concerned that continued expansion of the WUI would lead to greater constraints to the use of prescribed fire: *"As the WUI expands into rural areas, it gets harder to use fire because of the stricter regulations under the smoke guidelines for smoke sensitive areas. It gets worse with increased complaints from the residents moving in from other parts of the country who do not understand the role of fire in this region" – certified private burn consultant.*

"It is lack of knowledge among people in the region…… So it is lack of knowledge and ignorance about the value of burning and what it consists of, and the lack of knowledge is incredible" – private landowner.

At the same time, 60% of the respondents also believed that citizens understood the benefits of the use of prescribed fire and were more accepting of its use when they were exposed to information about prescribed fire. Thus, there was a strong belief among all study participants about the importance of communicating the rationale behind and expected benefits of prescribed fire use: *"Things work a whole lot better if you*

explain to people the reasoning behind prescribed burn. I have not had anybody voice a negative perception once the process is explained to them"- Private landowner.

Due to this perception, prior to our study managers had worked to develop a consistent message and pool resources across organizations to develop a variety of education and outreach programs in an effort to overcome the obstacle of low public awareness through the use of websites, school education seminars, television broadcasts and radio shows. Some ongoing partnerships among the federal, state, and local agencies, as well as the South Carolina Prescribed Fire Council are the "one message, many voices" campaign, and the creation of real-time websites such as goodfires.org that inform citizens about the benefits and use of prescribed fire. Noting these previous programs, participants also mentioned the need for increased public education and outreach: *"We need to continue to educate the general public. Start them young. We need to come up with another cartoon/campaign that puts a positive spin on fires" – South Carolina Department of Natural Resources employee.*

Although private burners (83%) were more likely to indicate that residents did not understand the use of fire, it was the agency managers who had taken the initiative to communicate with the public regarding the rationale for prescribed fire programs as well as communicate with potentially impacted stakeholders prior to specific burning activities.

4.2. Cognitive Factors

The interviews revealed various cognitive factors that influence the decision-making process for prescribed fire management in South Carolina. These factors include the role of risk and uncertainty, message frames, and the decision-heuristics of affect, availability and status quo. Table 4 lists each of these factors and the number of participants from the various government agencies, non-government agencies, and private consultants and landowners that were influenced by the factor. It also shows the overall percentage of respondents who were influenced by the factor in their decision to use prescribed fire.

Cognitive Factors	**# of participants**			**Overall %**
	Gov.	*NGO*	*Pvt.*	
Risk & Uncertainty - Liability and Public Safety	9	8	6	*85%*
Message Frame – Restoration	12	7	2	*78%*
Decision Heuristics & Biases				
a. Affect	9	6	5	*74%*
b. Status Quo	7	4	6	*60%*
c. Availability	7	3	3	*48%*
N	***14***	***8***	***6***	***100%***

Table 4: Cognitive factors affecting management decision making (n=28)

4.2.1. Risk and Uncertainty

Risk and uncertainty were the most frequently identified (85%) cognitive influence on participant decisions to use prescribed fire. In particular, participants expressed concern with potential legal liability and public safety, especially near smoke

sensitive areas. Private consultants and landowners (100%) were more concerned about liability and public safety from possible smoke hazards as compared to agency managers (60%) who recognized it as a greater challenge for private landowners to conduct burns on their property: *"Everyone is afraid of the liability issue of smoke and fire getting away, specially private landowners*" *– Turkey Federation employee.*

"Liability affects us because everyone is scared of burning so we end up being vulnerable to wildfire" – Private Landowner.

The fear of liability and public safety near major roadways resulted in the risk-averse behavior of private landowners. As one participant mentioned, he had not burned certain tracts of his land for a few years due to fear of liability and now *"burn consultants are apprehensive to use fire on my land for the past two years because of the larger fuel loads and increased risk to public safety from residual smoke near the highway" – Private landowner.*

Private landowners indicated the South Carolina Prescribed Fire Act contributed to these liability concerns due to perceived lack of protection. Because of this lack of coverage, private landowners indicated the need to carry private insurance, the cost of which was noted as a major deterrent to the use of prescribed fire: *"The biggest obstacle we have in South Carolina is the way the law is worded. If a burner does due-diligence as far as preparation and safety, there is no significant reduction of liability. The prescribed fire council is trying to change the wording so that is you are certified then you have documentation and do due-diligence, and something goes wrong then at least the law will provide you with some measure of liability protection. As far as general liability insurance goes prescribed burning is one of the most expensive components of that insurance" – Private burn consultant.*

4.2.2. Message Framing – Restoration

The words used to describe prescribed fire shows how managers think about their use of fire. Participants had a tendency to frame the decision to use prescribed fire as contributing to the restoration of the longleaf pine ecosystems (78%), rather than to maintain habitat for the RCW under the ESA (48%). This finding is relevant because the available frames could affect the motivation to use fire and perceptions of the expected outcomes of its use. As one participant noted: *"We use fire [for the restoration of the longleaf ecosystem] in an effort to hopefully restore its [original] range in the southeast that is down to 2% …. By doing so we are automatically maintaining RCW habitat." – US FWS employee.*

Moreover, 86 % of agency managers had a higher tendency to frame the decision as contributing to the restoration of longleaf pine, compared to 33% of private burners, even though 78% of the agency participants managed lands that had existing RCW populations on it and were thus required under the ESA to manage its habitat. Adopting a restoration frame may contribute to a greater acceptance of risks from the use of fire.

4.2.3. Decision Heuristics and Biases

Three types of decision biases were evident in participant responses: affect, availability, and status quo. Even though affect and availability tend to discourage the use of fire in prior research (Maguire & Albright, 2005), this did not appear to hold true among our respondents. Indeed, affect (74%) and availability (48%) had a positive

influence on the fire management decisions as participants indicated that ongoing use of prescribed fire in the region was associated with healthy longleaf pine ecosystem, RCW habitat, and healthy forests. In other words, examples of the beneficial use of prescribed fire are readily available to managers because of the history of successful prescribed fire use in this region. These examples also lend positive affect to the use of prescribed fires and encourage its use for land management: *"Prescribed fire has a successful history of being used to manage for timber, longleaf pine, and wildlife in this region without any catastrophic escapes in my memory. Instead wildfires like the Horry County fire in 2009 motivated various landowners to increase the use of prescribed fire to reduce the future risk of damage from wildfires. For the locals that was a wakeup call" – Hitchcock Woods employee.*

However, according to the participants, affect and availability may have an opposite influence on citizen support of prescribed fire due to urban expansion in the WUI. These participants noted that most urban residents, who are driving the population growth in the WUI, have had little previous experience with prescribed fires. Accordingly, most of their exposure to these issues comes from regional and national media coverage of catastrophic wildland fire events and escaped prescribed fires in other regions. They indicated that even though such events were uncommon in South Carolina, this media coverage made these event more 'available' to local residents: *"With the expanding WUI in an urban setting, and increased media coverage of western fires, there is confusion as to what prescribed burning really is. People don't make the distinction - Fire in the woods is fire in the woods. To them it's all wildfire, and not controlled or prescribed burn" –Military base employee.*

Most participants (60%) also demonstrated the tendency towards the status quo bias in the decision to use prescribed fire. In this case, prescribed fire was seen as a part of South Carolina cultural history and had always been used for traditional management of forestlands without the need to consider other alternatives. The status quo bias is related to the positive affect and availability heuristics, and together they combine to encourage greater use of prescribed fire in the region: "*The use of prescribed fire is favorable and has always been used and is a historically accepted practice in the region. It is a non - issue in South Carolina" – Private landowner*

Chapter 5: Discussion

This study explored the factors that influence the decision to use prescribed fire in South Carolina. Interview findings provide insight into how burn managers from government agencies (federal, state, and local), non-governmental organizations, and the private sector characterize the decision process regarding the use of prescribed fire. Several important points emerge from these findings and are discussed below.

The chapter begins by discussing prescribed fire as a historical and extensively used practice in South Carolina leading to positive affect and availability regarding its use. However, the ongoing expansion of the wildland-urban interface (WUI) may complicate the influence of these factors in the future. In addition, the potential for liability and impacts on public safety due to negative impacts of prescribed fire may lead to increased risk-aversion among fire managers.

Prior research shows a management tendency towards risk-aversion as constraining the use of prescribed fire (e.g., Maguire & Albright, 2005). However, our results suggest that prescribed fire is used extensively in South Carolina, and participants in general do not think of fire as a high risk management technique except in smoke sensitive areas. At the same time, factors that may increase risk aversion towards the use of fire appear to have an opposite effect among our respondents and contribute to the motivation to use prescribed fire. Several items contribute to this emphasis on prescribed fire use in South Carolina. First, prescribed fire is a part of cultural history in the region and has been used extensively on private and public lands

to manage forest conditions and meet management objectives. Rather than being viewed as a new or alternative technique as it is in much of the U.S., prescribed fire is recognized as the status quo for management in South Carolina. This perception of prescribed fire as a status quo management technique reduces the perceived risk and uncertainty associated with the use of fire (Samuelson et al., 1988). Furthermore, Slovic and Fischoff (1982) found that past experience tends to bias future judgments. Hence, positive experience with successful use of fire in the past could bias the forest management decisions towards the use of fire in South Carolina.

The history of prescribed fire use as a extensively used practice in South Carolina also tends to provide a positive affect and availability regarding its use. Affect and availability tend to have a positive effect on the use of fire among our participants. The history of successful fire use in South Carolina is associated with healthy forest ecosystems, wildlife habitat, and restoration of longleaf pine forests. These images can create a strong positive affect which reduces managers' risk perception associated with prescribed fire, and provides readily available examples of successful fire use. Thus, fire managers in South Carolina rely on these prior positive experiences to predict future outcomes of prescribed fire as lower risk when compared to managers in other regions in the United States. Conversely, prior research indentifies the potential long-term influence on support for prescribed fire use from an escaped fire (Winter et al., 2002), where past experience with catastrophic escaped fires has a tendency to sharply reduce the future use of prescribed fire due to the increased perceived probability of escape and a high negative affect associated with the event (e.g. Maguire & Albright,

2005). This risk-averse behavior was apparent despite statistics indicating that nearly all prescribed fires are maintained within prescription (Winter & Fried, 2000).

Moreover, the frame used by agency managers to describe the objectives of prescribed fire also contributes to its extensive use in the region. The manner in which a decision is 'framed' or formulated is known to have a strong effect on decision-making (Tversky & Kahneman, 1981: Kleindorfer et al., 1999), where the perception of risk is based purely on how the consequences of the decision are framed (Wilson et al., 2011; Kahneman & Tversky, 1979). Decision-makers tend to be risk-averse towards potential gains and risk-acceptant towards losses (Tversky & Kahneman, 1981). Prior research suggests that management objectives framed in terms of returning to an earlier better status, i.e. restoration, took precedence over an otherwise identical decision that was framed around the current status, i.e. maintenance (Gregory et al., 1993; Wilson et al., 2009). Moreover, using a restoration emphasis for "lost" forest health increased the willingness of individuals to support options that might be higher in risk or pose a risk of failure (e.g. prescribed burn) (Wilson et al., In Press). Most respondents in our study (78%) had a tendency to use the restoration frame for longleaf pine ecosystems over the maintenance frame of habitat protection under the ESA. It is possible that framing of the decision to use prescribed fire in such a manner might reduce the risk perception associated with its use and play a role in the extensive utilization of prescribed fire in the region. Additionally, the motivation to use fire for restoration might also overcome the potential constraints of the ESA that usually tend to make managers risk-averse due to a fear of escape damaging endangered species habitat.

However, even with the widespread use of prescribed fire to achieve multiple management objectives in the region, findings suggest that some factors may result in increased risk-aversion in the future and lead to additional constraints in the continued success of prescribed fire programs. Managers expressed concern that ongoing population and demographic changes in the local populations may lead to lower understanding and acceptance of the use of prescribed fire. Moreover, such changes are also likely to further emphasize existing concerns regarding the potential risk to public safety and legal liability expressed by burn managers.

WUI expansion was linked to an increase in risk-perception from prescribed fires because an increase in density in the WUI increases the number and proximity of smoke sensitive areas that can create a higher potential for liability issues arising from possible smoke hazards. Existing research cites the expansion of residential areas in the WUI as a primary factor that influences forest management decisions (Theobald & Romme, 2007), followed by liability and smoke management laws as the top barriers to prescribed burns (Haines et al., 2001). The South Carolina Smoke Management Guidelines require the reporting of the nearest smoke sensitive area and include stricter requirements for burns conducted in proximity to such areas. These regulations can be restrictive to the use of fire as the WUI expands and may result in risk-averse behavior by landowners as perceived risk to public safety increases with major highways and residential areas cutting across otherwise contiguous burning land.

Participants here were also concerned that such growth was resulting in a cultural shift among WUI residents as they believed the new arrivals had lower

awareness of the benefits of prescribed fire and would be less supportive of its use. However, existing studies show that in Florida, another Southeastern state where prescribed fire is an established practice, public acceptance among WUI residents tends to be high (Winter et al., 2006). It is important to note the Florida study primarily included long-term residents (over 10 years) while very few (1%) were new or seasonal occupants. While our participants indicate similarly high levels of support among long-term residents, an important question for the future will be whether such support changes as the demographics change as managers here expect. Prior research does suggest that urban expansion may constrain prescribed burns (Cortner et al., 1990; Miller & Wade, 2003; Haines et al., 2001).

While affect and availability have generally had a motivating influence on the use of prescribed fire to date among our participants, negative experiences could serve to modify the effect of these factors in the future. For example, while the impact of smoke on visibility was cited throughout the interviews as an issue of concern, it was particularly emphasized following a major smoke incident in Florida that occurred during the study period. In January 2012, a major smoke inversion from a wildfire in Florida caused a multi-vehicle accident and resulted in several fatalities on an interstate highway (CNN, 2012). This event received widespread media attention and was repeatedly cited in subsequent interviews. In total, participants in 13 of the 19 interviews that occurred after the Florida smoke incident highly emphasized public safety on the roads, and often used the Florida incident as an example for the extreme concern about public safety from smoke on the highway. This recent and vivid event

might have created a high negative affect, and increased the participants' risk perception and probability of possible smoke hazards from the use of prescribed fire. Negative affect can lead to a perception of high risk and low benefits, and availability determines the probability of the event (Alhakami & Slovic, 1994; Tversky & Kahneman, 1974; Slovic, 1995). While our data do not allow us to assess the lasting impact of this event, similar negative experiences with fire (possibly even with naturally-ignited fires as in this case), may contribute to increased risk aversion among managers particularly as the WUI population, residents and private property perceived to be in harm's way, continue to increase.

The concerns of personal liability were a leading factor for managers' expressions of risk aversion near smoke sensitive areas. This behavior seems rational given the potential of criminal and financial liability in the event of an escape. In our findings, private landowners were more likely to express concern about liability arising from smoke intrusions and escape of fire than government agency managers. This finding may be influenced by the timing of when interviews were completed (all of the interviews with private landowners were completed after the Florida incident); however, even agency managers often indicated that liability issues were a larger concern for private burners. Moreover, current liability laws in South Carolina exempt federal employees for using prescribed fire, while private landowners may be found liable for any resulting negative impacts. This exemption of federal employees for using prescribed fire could also contribute to their lower perceptions of smoke regulations as being restrictive to the use of prescribed fire as compared to private burn managers.

However, research elsewhere suggests that agency personnel are becoming more risk-averse due to a perceived lack of agency support in recent years, which increases the risk of liability (Canton-Thompson et al., 2008). In such cases, use of prescribed fire may be viewed as a potential career-ending decision.

Private burn managers indicated that current language in the South Carolina Prescribed Fire Act did not provide adequate liability coverage for burners and had a tendency to make private landowners risk-averse. The current law states that "no property owner or lessee or his agent or employee conducting a prescribed fire pursuant to this chapter is liable for damage, injury, or loss caused by fire, resulting smoke, or other consequences of the prescribed fire unless negligence is proven" (SC State Law, 2011). In legal terms, 'negligence' refers to negative impacts resulting from carelessness rather than intentional actions (Yoder, 2008). Private burn managers indicated this was a low standard that provided limited protection given the complex nature and several variables involved in fire management decisions. Thus, private burn managers felt compelled to adopt costly personal liability insurance to provide the necessary protection to conduct prescribed burns. Previous research has found that the high cost of legal liability, as described here, has contributed to decisions to not use prescribed fire (Yoder 2008).

The South Carolina Prescribed Fire Council has been advocating adding more inclusive language of 'gross negligence,' or serious carelessness, in the existing law to raise the standard necessary to claim liability for negative impacts from prescribed fire use on private lands and raise the bar to prove damages against the burner (Yoder,

2008). If such efforts are successful, it may contribute to reduced risk perception among private burners.

Chapter 6: Conclusion

Results from this project provide a deeper understanding of the factors that influence the managerial decision to use prescribed fire in South Carolina, and suggest the need for future research to add to further understanding of these factors and examine their consistency in other regions. Of the prior limited research conducted on burn managers, findings here suggest similar factors may influence decisions regarding the use of prescribed fire but in different ways depending on the local context and history of treatment use.

Although risk-aversion was extremely relevant in South Carolina, it was more nuanced than in previous research. In this study, risk-aversion due to fear of liability and public safety was an obstacle to conducting more frequent burns that are required to manage longleaf pine ecosystems and reduce future wildfire risk. Prior literature on risk-averse behavior of managers using prescribed fire has mainly considered agency managers; our results show that risk perceptions may differ depending on the participants examined, as risk aversion was substantially higher among private burners.

Local context was important for how risk-aversion affected fire management decision-making, where the history of prescribed fire use in South Carolina made the burns seem less risky. Comparing these results across various regions could help in further understanding of the factors that contribute to the extensive use of fire in South Carolina when compared to western regions.

Participants were extremely concerned about urban expansion causing future obstacles to prescribed burns. Due to the nature of land ownership in southern states, there is a high degree of in-holdings and substantial interface between public and private lands. Such a situation means that most prescribed fires are likely conducted in relatively close proximity to private property. Such conditions also contribute to a high proportion of WUI lands in the southeastern U.S.

As with many of the results here, these changes suggest both potential motivation and constraints to the future use of prescribed fire. Moving forward, questions regarding the ability of managers to continue to use prescribed fire, on both public and private lands, will likely be influenced by the interplay of legal and regulatory frameworks for treatment implementation, social influences including treatment acceptance and demographic changes, as well as cognitive factors among burn managers and the general public. While the recent traffic accident in Florida suggests that even influences from outside the study location may influence local perceptions, local managers have a strong base of acceptance among rural residents and ongoing success of the local programs to provide the foundation for effective programs in the future.

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Appendix: Interview Guide (Agency Personnel Interviews)

Introduce ourselves, project, describe informed consent, obtain signatures, and start recoding.

1. ROLE WITH FIRE - Describe your role within this community with respect to forest health, threat of wildfire, fuel reduction and smoke management
    a. For the land you manage - do you use prescribed fire?
    b. What is the acreage you burn? How frequently do you burn?
    c. What influences your decision to use (or not use) prescribed fire?
    d. How do you manage smoke issues? What influences smoke management decisions
        i. What is the general public opinion about smoke from prescribed and wildland fire
    e. Who do you notify about your plans to burn
    f. Are your management decisions/actions influenced by any local, state, or federal policies? How so?
        i. How about influences from local citizen groups and management agencies?
2. ORGANIZATIONS - Which are the most important public and private organizations in determining fire management practices in this region?
    a. Specific individuals (or groups) that influence these organizations? How so?
    b. Are you involved in any partnerships related to land or forest management in the area? If so, please describe.
    c. Which agencies and organizations do you work with in regards to land, fire, and smoke management
        i. Are you part of any organizations that partner with agencies like FWS, NPS etc.
        ii. Who do you trust? How do you work together?
        iii. When did the relationship start?
        iv. Do you feel that agencies manage the forest around you in a satisfactory way?
3. PRACTICES - What are the most commonly used fuel management practices in SC?
    a. What is the level of acceptance of these practices?
    b. What factors do you feel influence that support?
        i. If respondent does not identify smoke, **ask**: You did not mention smoke as a factor that influences support for the use of prescribed fire. Do you think it influences acceptance in the region?
4. COMMUNICATION - What forms of communication do individuals or groups use to interact with one another about prescribed fire and smoke issues?
    a. Which ones are the best, and in which situations? Most trustworthy?

b. Where do you get good information about fire management practices and programs? – lung association and commissioner, not military
c. How open are government management agencies to citizen involvement in planning processes?
    i. Lung Association - interactions with the state/federal managers.
    ii. How do individuals or representative groups influence decisions
d. What is the role of collaboratives or partnerships in the region?
e. What do you feel about the regulations of county and state? Are they conflicting?
f. Do you feel you get a consistent message about burns from air quality and burners?

5. PERSONAL SMOKE - Have you experienced a smoke event from prescribed or wildland fire in the last ten years? Tell me about it.
    a. Have there been any substantial smoke events in the last ten years?
    b. Was it acceptable for you? What things influence the acceptability of smoke?
    c. Does the source of smoke matter?
        i. Planned vs. unplanned ignitions?
        ii. Agricultural vs. prescribed burns in forests?
6. SMOKE CONCERNS - What are your main concerns with smoke emissions?
    a. How can they be addressed by managers?
    b. How do you feel about the smoke from burns in the area? Does it hamper the way of life?
    c. What about the burn do you feel is the biggest concern?
        i. Road shutdowns due to smoke? Major issue?
7. TRADE-OFFS - Fire and fuel management often involve difficult tradeoffs, how would you characterize the tradeoffs regarding smoke emissions?
    a. What are the benefits from prescribed fire use? Are those benefits worth the smoke emissions?
    b. Would you accept smoke in exchange for a reduction in fire risk for the surrounding forest?
8. O&O - What obstacles and opportunities exist for developing and implementing prescribed fire and smoke policies? Any ideas about overcoming these obstacles?