An Analysis of the Social and Technological Factors Influencing Team Performance in Wildland Fire Incident Management Teams

Dissertation

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Abstract

Wildfire is a difficult environmental hazard to manage. While uncontrolled wildfires can pose considerable risk, overly-aggressive suppression degrades fire-adapted ecosystems and increases the risk of catastrophic wildfires in the long run. The fire managers and incident management teams (IMTs) who manage fires must make decisions in rapidly evolving situations characterized by high risk. Many factors inform these decisions, and fire managers must choose how they will seek out and attend to information. Information may come from technological sources such as decision support tools, or social sources such as trustworthy supervisors and subordinates. IMT members have a suite of decision support tools available that provide information on a variety of attributes, such as values at risk, forecasted weather, and projected fire behavior. However, it is not clear how IMT members use things like weather information to inform their tactical decisions. In Chapter 1, we review the psychological dynamics of fire manager decision making and the social dynamics of wildland fire management teams that influence what information fire managers use, and how they use it. In Chapter 2, we use a choice experiment to evaluate how IMT members use forecasted precipitation, humidity, and wind when making tactical decisions. Results show IMT members actively use weather information and generally prefer to directly attack fires exhibiting moderate fire behavior and indirectly attack fires exhibiting extreme fire behavior. However, how much importance fire managers assign to weather information depends on the previous tactics being used up until that point. Based on these results, we recommend future efforts to improve reliability and confidence should target precipitation and wind models. We also recommend decision support

tools, including weather forecast tools, be designed with the probable decision strategies of the end users in mind. We also evaluate how trust dynamics between team members influence team performance. In Chapter 3, we interview IMT members about the characteristics they look for in trustworthy supervisors and subordinates, and what they believe those team members look for in them. IMT members show consistency in trust referents: what they value in supervisors, they believe their subordinates value in them and vice versa. Ability, benevolence, integrity, predictability, and gender influence trustworthiness, but their relative importance depends on the trust referent. These results point to the need to interrogate whether the accepted symbols of competence used and accepted by fire managers accurately reflect the skills valued in teams. As well, results suggest several ways for team members, especially supervisors, to improve their trustworthiness. In Chapter 4, we survey IMT members to assess how trusting and being trusted by one's supervisor influences overall team learning and team performance in IMTs. While trustworthy supervisors positively contribute to team performance mediated by team learning behavior, feeling trusted by supervisors was not statistically significant. These results reveal the important role supervisors play in overall team-functioning and highlights which trustworthiness characteristics are valued in supervisors. As well, results suggest trust and felt trust are conceptually similar, but not identical and future research should proceed with caution before using reflexively-worded trust scales to measure felt trust. Future work should evaluate the effect of not only the respondent-supervisor trust dyad, but the respondent-subordinate dyad as well. In Chapter 5, the presented work is summarized for a practitioner and policy audience in the form of three research briefs. These research briefs are structured in line with Lake States Fire Science Consortium Research Briefs guidelines. Briefs are 500 – 800 words, including an overview, methods, and combined results and implications

section. They include a key figure or table to communicate findings and have 3 - 5 bulleted management implications.

Dedication

To SDR from SFB.

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Fields of Study

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Chapter 1. Introduction and Literature Review

1.1 The Human Dimensions of Wildfire Management

Wildfire is a vexing environmental problem. Although the number of acres burned varies considerably from year to year, between 2011 and 2020, on average 7.5 million acres burned annually (Hoover & Hanson, 2021). Most fires are contained and suppressed within 48 hours of the fire igniting, the majority of acres burned are due to the fewer than 5% of fires that become large, escaped fires (Calkin et al., 2005). The majority of the land directly affected by wildfires is owned by the federal government, especially land managed by the US Department of Agriculture's Forest Service (USDA Forest Service) and Department of Interior. These agencies have jurisdiction over wildfires ignited on and burning onto their land and engage in pre-fire planning (e.g., fuels reduction and resource staging), fire response (e.g., suppression or management of ongoing fires), and post-fire recovery (e.g., restoration of landscapes affected by wildfires).

Uncontrolled wildfires pose a danger to lives, property, and ecosystems. However, wildfire is a key part of many fire-adapted ecosystems. Fire response that favors aggressive suppression makes fires worse in the long-run and can have negative ecological impacts (Calkin et al., 2015; Dale, 2006). Modern fire management is challenging, exacerbated by fuel build-up from a legacy of fire suppression (Calkin et al., 2015), climate change (Westerling, 2016; Westerling et al., 2006), and the expansion of the wildland urban interface in fire-prone areas (Radeloff et al., 2018; Theobald & Romme, 2007). Current wildland fire policy is guided by the Cohesive Strategy, which outlines three goals for fire management in the United States (US): 1)

restoring and maintaining resilient landscapes, 2) creating fire-adapted communities, and 3) responding to wildfires (USFS & OWFC, 2011). Although public land agencies have tried to increase flexibility in fire management by allowing fires to be managed for multiple goals, in many cases agency personnel still suppress fires that pose relatively low risk to infrastructure or resources but could provide benefit for ecosystems (Schultz et al., 2019; Steelman & Burke, 2007).

There are many reasons why the dominant paradigm of fire management is still aggressive suppression despite decades of research advocating for more fire use and fire management (Thompson, 2014). Areas in proximity to development (called the wildland urban interface) are often managed as suppression only and local policy does not allow for fires to be managed for resource benefit (Steelman & McCaffrey, 2011). Even in areas where fire managers have flexible policy that allows suppression or resource management, fire managers face pressure to suppress fire from many sources, including the public and local politicians (Donovan et al., 2011; Gude et al., 2013). Fire managers may also experience pressure from their own agencies where fire managers may perceive mixed messages regarding preferred fire management approaches. For example, managers with decision-making authority in the USDA Forest Service have indicated they feel unrewarded for risk-taking (Kennedy et al., 2005) and the National Forest System and Fire and Aviation Management branches of the Forest Service do not necessarily have aligned incentives, values, or goals (Schultz et al., 2019). Psychological factors play an important role in fire manager decision-making as well. Some public land managers are especially risk-averse, fearing they will be held accountable if decisions to manage fire for reasons other than suppression go awry (Canton-Thompson et al., 2008). Similarly, they may engage in sunk cost bias, continually committing resources to a fire that is resistant to

control. For fires that exhibit extreme behavior, many resources will be ineffective at containment. In those instances, fire managers may be most encouraged to commit considerable resources to a fire when those resources are the least effective (Calkin et al., 2012; Thompson et al., 2018). In addition, empirical research suggests fire managers are risk-averse and susceptible to framing effects and cognitive biases (Calkin et al., 2012; Hand et al., 2015; Wibbenmeyer et al., 2012; Wilson et al., 2011).

It is in this context that considerable effort has gone towards improving risk management and decision making and the overall functioning of fire management teams that respond to fire events. The research on the psychological factors that contribute to fire manager success during fire events can be largely divided into two fields. The first field has focused on information processing and decision-making under risk and uncertainty, including how biases and heuristics can lead to systematic errors in decision-making and how the design of decision support tools can foster better risk management. This work seeks, for example, to develop tools to aid in deliberative pre-fire planning (O'Connor et al., 2016; Thompson et al., 2018) and strategic fire response (Calkin et al., 2011). The second field has focused on the social-psychological context of fire managers and the teams they work on. This work seeks, for example, to understand the social and interpersonal skills sought in suppression leaders (Boyatzis et al., 2017) and the team behaviors that contribute to sustained coordinated decision-making across team members (Bearman et al., 2015). This review considers these two bodies of work in turn and identifies current gaps in our understanding of the technical and social-psychological drivers of fire manager decision making during fire response. The gaps identified are addressed in subsequent chapters, namely how fire weather tools influence tactical decision making (Chapter 2); what characteristics contribute to trustworthiness in team members

(Chapter 3); and how trust in and felt trust from supervisors affects how the team learns from one another and achieves their fire management goals (Chapter 4).

1.2 Information Processing and Decision Support

In the context of wildfire, risk management is "a set of coordinated processes and activities that identify, monitor, assess, prioritize, and control risks that an organization faces" (Thompson *et al.* 2016, pg. 4). Researchers endorsing a risk management paradigm for wildfire management often argue that better information about the values at risk and the consequences of exposure will improve decision-making (Noonan-Wright et al., 2011). As argued by Calkin et al. (2011), "by focusing on risk, the intersection of threat (fire spread) and values susceptible to loss, fire managers are more likely to deploy suppression resources where they may most effectively reduce loss" (Calkin, Thompson, *et al.* 2011, pg. 278). To this end, have been developed that provide information about weather, fuels, fire behavior, and values at risk to inform decisions ranging from pre-fire preparedness to final mop-up activities. However, the presence of risk-relevant information does not necessarily mean fire managers will engage in better risk management decisions for several reasons. First, the presence of information does not mean fire managers will assimilate and use it. Fire managers must make choices about how much information they will consider before making a decision based on their time, capacity, and expertise (Drews et al., 2015). In addition, the source of the information plays an important role in how fire managers judge validity and utility. Fire managers are much less likely to use risk-relevant information if they do not trust the individual from whom the information is coming (McLennan et al., 2006; Rapp et al., 2020).

Second, current wildland fire decision support tools largely assume the tools will facilitate a stepwise, analytic-deliberative process that follows rational actor models where fire

managers make choices by calculating the alternative with the highest utility (Zimmerman, 2012). However, because of time and resource constraints, this may not be an accurate representation of the decision-making style of fire managers. Fire managers work in time-pressured and dynamic environments and may use decision making strategies more in line with recognition-primed decision making (RPD). In RPD, experts are described as making decisions based largely through intuition and by identifying patterns in the current situation that align with their prior experiences (Klein, 2008; Klein et al., 1986). More specifically, the RPD model of decision making would predict that decision-makers with relevant experience, under time pressure with uncertain or ill-defined goals do not routinely compare alternatives and make tradeoffs, but rather assess the familiarity of the situation, identify a single course of action deemed appropriate for such situations, and modify that approach until it feels sufficient for implementation in the current situation (Klein et al., 1989; Lipshitz et al., 2002). This decision strategy is evident in how fire managers use information; experienced fire managers can make reliable decisions with less information and time than novice fire managers (Drews et al., 2015) and existing decision support tools are often used not to evaluate alternatives as originally intended, but as a "gut check" that their intended plan will work (Rapp et al., 2020).

Third, the decision space of fire managers is constrained by the hierarchical nature of fire management. In the US, large fires that escape after the first 48 hours of suppression and containment (called initial attack) are managed by incident management teams (IMT; National Wildfire Coordinating Group, 2013). An IMT is headed by an incident commander, who operates as the liaison to relevant stakeholders and manages the overall IMT. For wildfires on public land, IMTs may be called in from outside the local area when a fire exceeds local capacity. Wildfire management includes two levels of decisions – those made at a strategic level that guide overall

objectives for the fire, and tactical decisions about how the specific fire event is managed to achieve those strategic priorities. Incident commanders work with the local personnel in charge of the day-to-day management of the land where the fire is occurring to outline strategic objectives. Strategic decisions concern the overarching strategy of the fire and include developing incident alternatives and objectives, focusing on broader scales and longer time periods (Taber et al., 2013). These strategic objectives may be updated continuously as the fire progresses. In comparison, tactical and operational decisions are made about the operational actions to be taken to achieve strategic goals and include resource placement and fire management tactics. Generally, the IMT is given discretion to make tactical decisions. In addition to the incident commander, the IMT includes additional sections with responsibility for specific aspects of the fire. Depending on the complexity and size of the fire, IMT's may include Operations, Planning, Logistics, Finance, Information, Safety, and Liaison, each headed by a respective chief (National Wildfire Coordinating Group, 2013). The IMT is further divided and hierarchically arranged with each unit reporting to their respective chief, supervisor, or leader. The decision space of each individual fire manager within an IMT is therefore shaped by their position in the IMT hierarchy, which means the potential leverage of a decision support tool depends on the role of the individual who may be using the tool.

Existing decision support tools primarily focus on influencing strategic decision making. These tools can be used by operations personnel to shape tactics (Noble & Paveglio, 2020; Rapp et al., 2020), but there are many challenges to creating formal decision support tools for operations (Dunn et al., 2017). However, an abundance of information sources, not formal decision support tools (which facilitate tradeoffs by enumerated the consequences or outcomes of different alternatives), exist to shape tactical decision-making. Weather information plays a

particularly important role in fire behavior and subsequent fire outcomes (Countryman, 1972). Operations personnel have a variety of weather information available to them to inform tactical decision making at all stages of fire management and at different spatial scales. On active fire events, fire managers may use local spot weather forecasts (Wall et al., 2017). On extended fires with IMTs, an incident meteorologist (IMET) may be assigned to produce local weather forecasts specifically for the fire. These forecasts in turn can be folded into fire behavior models produced by other technical specialists on the IMT.

Weather forecasts may be used by operation personnel to inform a variety of decisions. Weather information can be used to assess the likelihood of success for a particular tactic (Rapp et al., 2020) and guide resource ordering based on expected fire behavior (Bayham et al., 2020). However, despite the ubiquity of weather information in fire management, relatively little is known about how precisely fire managers use weather information; what pieces of information do they attend to and how do they use it? In Chapter 2, we explore how fire managers use fire weather forecasts to choose between two potential tactics. Using a web-based choice experiment embedded in a survey, we assess the relative importance of forecasted precipitation, humidity, and wind, time in season, and energy release component on the decision to directly or indirectly attack a fire that has escaped initial attack and is transitioning to extended attack. We also evaluate fire managers' relative confidence in weather forecasts generally as well as specific forecasts for humidity, precipitation, and wind.

1.**3** Social-Psychological Team Dynamics

Although access to technical information such as fire weather and projected fire behavior, and thoughtful processing of that information, are undoubtedly important for effective fire management and risk-informed decision-making, the social dynamics between

team members also shapes individual decision making and subsequent team performance. The importance of interpersonal dynamics is recognized by IMT members; social and emotional intelligence is valued in incident commanders (Boyatzis et al., 2017), and non-operational qualities such as integrity and sincerity are valued in supervisors (Waldron et al., 2015; Waldron & Schary, 2019). In fact, clear and effective communication skills, effective leadership, and knowledge of the incident management system structure have been identified by IMT personnel as key competencies (Hayes & Omodei, 2011).

Communication skills are important because IMTs must maintain a shared understanding of the fire as conditions change across time and space. This shared understanding is predicated on the exchange of information; team members must both give information and assimilate information received. As discussed earlier in the context of decision support tools, the relationship between team members shapes this flow of information. As argued elsewhere trust is critical for the efficient flow of information (McLennan *et al.* 2006); information from trusted team members is actively assimilated while information from untrusted team members, especially incongruent or surprising information, is treated with skepticism. The importance of trust between individuals is highlighted in several studies of IMTs and the broader incident command system (Bigley & Roberts, 2001; Jensen & Thompson, 2016; Moynihan, 2008). Despite its stated importance, studies of IMTs to date have largely assumed trust is important without directly measuring or examining trust. It is not clear what characteristics IMT members look for in each other when evaluating trustworthiness, and although it is hypothesized that trust influences communication, this has not been empirically tested.

Despite the limited work focusing on IMTs, lessons can be drawn from research in organizational psychology on trust between team members. Trust is a critical component of

working in teams in routine settings, or work teams. Trust in work teams and supervisors is associated with greater information and knowledge sharing (Chowdhury, 2005), better team performance (de Jong et al., 2016), and greater risk tolerance (Clark, 2016; Schoorman et al., 2016). Researchers across many domains and disciplines have studied trust. Two commonly cited definitions of trust are those by Mayer *et al.* (1995) and Rousseau *et al.* (1998). Mayer *et al.* (1995) define trust as "the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party" (p. 712). Similarly, Rousseau *et al.* (1998) define trust as "a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behavior of another" (p. 395). These definitions suggest two key components of trust on behalf of the trustor (the person who is expressing trust): 1) positive expectations of trustworthiness towards the trustee (entity being trusted) and 2) willingness of the trustor to accept vulnerability in the face of uncertainty (Fulmer & Gelfand, 2012). Individuals express trust through their behaviors, including relying on trustees to complete tasks and through disclosing sensitive information to trustees (Breuer et al., 2019; van der Werff & Buckley, 2017). Trustors and trustees can be individuals, groups, or institutions. In wildfire management, trust may be evident in many different types of relationships, such as an incident commander trusting their operations section chief to make tactical decisions with minimal oversight, the line officer trusting the IMT to manage the fire effectively, and the public at large trusting emergency personnel to keep them safe.

Mayer *et al.* (1995) proposed the integrative model of organizational trust to further distinguish trust from its antecedents that contribute to the development of trust: trustworthiness and propensity to trust. Trustworthiness is an assessment of the traits of the

trustee, including ability, benevolence, and . Propensity to trust is a trait of the trustor, describing their general willingness to trust regardless of context (Schoorman et al., 2007, 2016). According to Mayer and colleagues (1995), ability refers to the context-specific skills, competencies and characteristics of the trustee that enable them to sufficiently complete the action, benevolence is the extent to which the trustee wants to do good to the trustor regardless of any egocentric motive or incentive, and integrity refers to the belief that the trustee adheres to an acceptable set of principles and values. Some scholars have suggested the integrative model is incomplete. The criticisms they provide vary as some authors suggest predictability or familiarity with the trustee should be added to the model (Dietz & Den Hartog, 2006), while others suggest the model needs to be validated and adapted for teams that work in vastly different environments than the integrative model was originally designed for, such as virtual teams (Breuer et al., 2019) or military teams (Brandebo et al., 2013).

These criticisms may apply when using the integrative model to study IMTs. While many studies using the integrative model take place in an organizational setting that examines teams and supervisors, this is not analogous to IMTs, which are large teams of highly trained professionals assigned to specific roles over the course of a disaster. Additionally, decision-makers in IMTs are embedded in a hierarchy, and even the incident commander reports to a supervisor while simultaneously delegating authority to those below them in the fire chain of command. Previous researchers have called for more research that considers trust across multiple levels (Fulmer & Gelfand, 2012). To understand how trust affects fire managers it is imperative to consider multiple trust referents (e.g., examining both trust in supervisors and trust in subordinates) as individual fire managers are embedded in networks and rely on

connections to diverse actors (Faas et al., 2017; Nowell et al., 2017). Thus it is likely these multiple relationships simultaneously influence individual decision-makers.

In addition, even when considering multiple trust referents, trust relationships are incomplete without considering the phenomena of both trusting and feeling trusted (referred to as "felt trust"). Compared to trust, less is known about the process and outcomes of feeling trusted by a person, team, or organization. Importantly, trust in someone and feeling trusted by that same person are not necessarily related; there is little reason to believe two people in a dyad must have the same level of trust or agree on the quality of the relationship (Brower et al., 2000). While research to date has examined the positive and negative ramifications of being trusted in organizational settings, the results are mixed as some studies find that feeling trusted can improve performance and foster cooperative behaviors (Lau et al., 2014; Salamon & Robinson, 2008) while others suggest that feeling trusted may cause stress and anxiety over maintaining one's reputation (Baer et al., 2015). Further, a more fundamental question has not been asked yet: do individuals use the same evaluative criteria to determine trust and felt trust? Although no research to date has addressed this question directly, evidence suggests individuals use different criteria to determine whether to trust someone and whether they believe that person trusts them. While trust is expressed by relying on and disclosing information to the trustee (Breuer et al., 2019; van der Werff & Buckley, 2017; Zand, 1972), studies on felt trust suggest disclosure may be less important than reliance for feeling trusted (Lau et al., 2014; Zheng et al., 2019), although it is unclear to what extent this is context- or task-dependent.

There is a clear need to both clarify how fire managers evaluate and experience trust on IMTs and assess how trust and felt trust influences team dynamics. These needs are addressed in Chapters 3 and 4. In Chapter 3, we assess the psychological antecedents of trust and felt trust

in supervisors and subordinates. Results are presented from interviews with 27 respondents working in mid-to-upper level positions in IMTs about what they look for in trustworthy supervisors and subordinates, and what they believe subordinates and supervisors look for in them. We compare these results to the integrative model and build a preliminary model of trust and felt trust within IMTs. In Chapter 4, we focus on the respondent-supervisor dyad. Informed by the results of Chapter 3, we survey over 300 mid-to-upper level IMT members on their experience working on IMTs. We model the psychological antecedents of trust and felt trust, and evaluate how trust and felt trust influence overall team learning and subsequent performance.

Chapter 2. The effect of weather information on fire manager decision-making: a choice experiment (published in *Fire Ecology*)

2.1 Introduction

2.1.1 Purpose

Reintroducing fire to the landscape and transforming the fire management paradigm away from aggressive and costly suppression towards thoughtful risk management requires shifts in practice at both tactical and strategic levels of fire management from initial attack in the earliest stages of a fire to mop-up activities as fires end. As fires progress, each decision will shape and constrain opportunities for future decisions. For example, nearly 88% of all fires in the United States from 1992 – 2018 were contained during initial attack and kept small (<10 acres) (Short, 2021)but defaulting to containment and suppression goals during initial attack shapes the decision space of future fire managers by contributing to landscape conditions that increase the long-term risk of catastrophic, uncontrollable wildfires (Calkin et al., 2015). (Calkin et al., 2015)

Fostering risk management also requires consideration of how decisions are made under risk and uncertainty. Decision making with risk involves choices where the exact outcome is unknown, but the possible outcomes that could occur, and their probability of occurring, are known. In comparison, decision-making under uncertainty involves making decisions when possible outcomes are not known, or their probability of occurring are not known. Fire managers work in uncertain and time-pressured environments and may not have the time or ability to deliberatively consider all information available to them. When people have insufficient time or resources to process information, they often rely on heuristics. Heuristics are simple rules and guidelines, or mental shortcuts meant to simplify and speed up decision-

making by emphasizing some information while ignoring other information (Gigerenzer & Gaissmaier, 2011; Simon, 1956). Heuristics can be adaptive as they can enable decision makers to make acceptably accurate decisions more quickly in some cases (Gigerenzer, 2008; Kahneman & Klein, 2009). However, heuristics can also systematically lead people astray from relevant information that could support more effective decision-making. Thus, heuristics can bias decision-making. There are a number of known biases that are regularly evident in decision-making. Among these, some common biases relevant for fire management include the availability bias, where one over-estimates the probability of events they have recently experienced occurring again in the future, and the phenomenon of anchoring-and-adjustment, where decision makers anchor to initial information they receive and insufficiently adjust their beliefs in response to new information (Maguire & Albright, 2005; Tversky & Kahneman, 1974).

Even experts with years of training and experience in a particular decision context are prone to cognitive biases. A growing body of research has specifically examined the decisions of fire managers. These studies find that fire managers are subject to many of the same biases as others. In particular, research has found that fire managers appear risk-seeking (i.e., more willing to accept risky alternatives than alternatives with a fixed outcome) when choices are framed as the opportunity to minimize losses, but risk averse when the same outcomes are framed as maximizing gains (Wilson et al., 2011); this apparent contradiction in decisions based on how they are described was first recognized by Kahneman and Tversky (1974). Fire manager are also influenced by framing with regards to personnel safety; when information is framed in an affectively-rich way, fire managers are more sensitive to personnel exposure than when information is presented analytically (Hand et al., 2015). Moreover, fire managers work in conditions of risk and uncertainty that may lead them to exhibit myopia, or excessive

discounting of future outcomes in favor of short-term gains (Maguire & Albright, 2005). Finally, fire managers display non-linear probability weighting; managers are more sensitive to changes in probability of success over moderate probabilities than low or high probabilities (Wibbenmeyer et al., 2012). While several decision support tools have been developed to support thoughtful and deliberative decision-making (e.g., Calkin, Thompson, Finney, & Hyde, 2011), the mere presence of additional information may not lead to more defensible or risk-informed decisions (Drews et al., 2015; Noble & Paveglio, 2020; Rapp et al., 2020). The purpose of this paper is to contribute to this growing body of literature by exploring how fire managers use weather information in tactical decision-making. We focus on a key decision point for large fire management, the transition from initial to extended attack. Specifically, we examine how fire managers use weather forecasts when deciding whether to directly or indirectly attack a fire 48 hours into an event. We chose this decision context because the transition from initial to extended attack marks an increase in complexity and is frequently accompanied by new personnel arriving on the incident.

2.1.2 Literature Review: Tactical Decision-Making and Fire Weather

On large fires that escape initial attack, the Incident Command System provides the framework for who has strategic and tactical decision-making authority. Under this system, line officers (e.g., local agency personnel with decision-making authority) work with incident commanders to establish the strategic objectives for the fire. Strategic objectives pertain to the overarching strategy of the fire, such as whether it will be managed for suppression, resource benefit, or both and where (Taber et al., 2013). In comparison, tactical decisions are made by the incident management team (IMT) and pertain to on-the-ground decisions about how the fire will be managed to achieve the strategic objectives. For example, the line officer might identify

protecting a high-value watershed as a strategic objective, leaving the IMT to make the specific tactical decisions about what resources to deploy where to protect the watershed. While strategic objectives fundamentally inform the decision space of the IMT, the tactical decisions of the IMT will also shape the final fire outcomes. For example, on fires strategically managed for either suppression or fire use, the IMT may decide to attack the fire directly (constructing a fire line along the active fire perimeter) or indirectly (constructing the line away from the perimeter and possibly conducting burnout operations).

Tactical decisions about how a fire is managed are not well understood in terms of both how they are made and how they influence fire outcomes. Specifically, while fire size, weather, and landscape characteristics are related to the ultimate financial cost of a wildfire, it is unclear how they influence tactical decisions like resource ordering and deployment (Hand et al., 2017). Further, it is difficult to quantify and evaluate how effective certain resources are at containing and controlling fires (Thompson, Rodríguez y Silva, et al., 2017). Without understanding resource effectiveness, it is difficult to evaluate, for example, whether dozers or hand crews would be more efficient for a given area (Plucinski, 2019). Given these conditions, it is difficult to calculate efficient tactical alternatives or provide tools to aid managers as they select between alternative tactical actions (Dunn et al., 2017). Several decision support tools have been developed to aid strategic decision-making (Calkin et al., 2011; Thompson, Calkin, et al., 2017; Thompson & Calkin, 2011), including the Wildland Fire Decision Support System (WFDSS) (NIFC, 2019) and more recently, potential wildland fire operational delineations (PODs) (Thompson, Bowden, et al., 2016). These tools can provide tactically-relevant information, but have some limitations. For example, PODs do not provide dynamic information over the course of large fire events (O'Connor et al., 2016). Similarly, WFDSS cannot help fire managers evaluate and

compare the outcomes of different alternative tactical actions. However, the fire behavior and weather information it provides can inform the feasibility and likelihood of operational tactic success (Rapp et al., 2020).

Indeed, weather information is critical to the likely success of wildland fire operations because weather, along with fuels and terrain, is one of the primary drivers of fire behavior (Countryman, 1972). Weather information is so important to wildland fire fighting operations, it is listed as the first of 10 Standard Fire Orders (systematically organized rules applied to all fires) that are taught to every firefighter on their first day of training: “Keep informed on fire weather conditions and forecasts.” Fire behavior characteristics, such as flame length, fire intensity and spread rates, determine how safely firefighters can directly engage a wildfire and these factors may be used heuristically to guide choices of fire suppression tactics such as direct or indirect attack (Andrews et al., 2011). Weather conditions that promote rapid spread and high intensity can prevent initial firefighting resources from containing a new fire (Arienti et al., 2006), leading to a fire that spreads out of control for extended periods of time. Low relative humidity, strong near-surface winds, an unstable atmosphere and severe drought can promote extreme fire behavior and make wildfires difficult to control (Tedim et al., 2018; Werth et al., 2011). These extreme fires often burn more area or cost more to suppress than fires that do not occur during extreme fire weather (Fernandes et. al., 2016; Finney et al., 2009; Hand et. al., 2017).

Firefighters and fire managers are accustomed to assimilating fire weather information in a range of forms and from a variety of sources. This information can impact decisions made at a variety of temporal scales and across a range of administrative levels. For example, weather information, often transformed into fire danger indices such as the Energy Release Component (Jolly et al., 2019), can be used to support pre-incident planning such as seasonal staffing, open

burning restrictions, and public awareness activities aimed at preventing human-caused wildfires. This weather-derived information is also used to inform 'run cards' that determine the numbers and types of firefighting resources dispatched during initial attack when fires do occur (Schlobohm & Brain, 2002) . During initial attack, fire managers monitor local weather conditions and request spot weather forecasts specific to their location (e.g., Wall, Brown, & Nauslar, 2017) to assess the potential for rapid changes in fire behavior that could affect their safety or that could impact local communities or valued resources. If fires are not contained through local management efforts and IMTs are assigned, local weather forecasts are often produced on-site by an Incident Meteorologist (IMET) and forecast information is provided daily as part of the Incident Action Plan. For large fires that escape initial attack, fire managers are required to create a Published Decision through the Wildland Fire Decision Support System, which uses weather forecasts to inform fire spread and behavior projections produced by the Wildland Fire Decision Support System (Noonan-Wright et al., 2011). A Relative Risk Assessment (RRA) is a component of these published decisions and these are developed collaboratively using observations, models, and data and are intended to capture the risk/reward basis of each decision and they are updated throughout the duration of the event as conditions change (Noonan-Wright & Seielstad, 2021). The resulting information is used to minimize firefighter risk, maximize likelihood of containment success, and protect communities and infrastructure. As these examples illustrate, the use of weather information is ingrained into the wildland fire system. In fact, evidence suggests IMTs order resources less based on previous fire activity and more based on weather forecasts and their projected impact on fire behavior (Bayham et al., 2020). Given the importance of weather information to fire management decisions, it is critical to understand how weather data are used to ensure the best possible information is available

for time-sensitive, tactical decision-making across a range of administrative levels and temporal scales.

While the provision of weather information is critical, the presence or availability of information does not guarantee its use by the IMT (Drews et al., 2015; McLennan et al., 2006; Noble & Paveglio, 2020; Rapp et al., 2020). Existing decision support tools are intended to help fire managers engage in deliberative, stepwise decision-making (Zimmerman, 2012); however, in practice, fire managers may still use the information provided by these tools, including weather forecasts, in a heuristic way. Specifically, fire managers may use weather information to recognize patterns and assess the extent to which a situation is similar to their previous experience (Drews et al., 2015; Klein, 2008; Lipshitz et al., 2002). Further, fire managers are susceptible to cognitive biases like framing effects, where the presentation of information influences preferences (Hand et al., 2015; Wilson et al., 2011). IMT personnel may feel pressure from the line officer, agency, or the public in general to manage fires in ways they may not believe is ideal. For example, spending more money and using tactics they believe are ineffective but the public wants to see, such as the ineffective use of aviation resources during periods of extreme weather (Calkin et al., 2012; Canton-Thompson et al., 2008). These challenges with using weather information are not unexpected or an inherently negative evaluation of fire managers, who operate in an environment categorized by considerable uncertainty, high risk, and multiple constraints (Kahneman & Klein, 2009; Thompson, Rodríguez y Silva, et al., 2017). However, it does ultimately suggest weather information may not be interpreted consistently across decision-makers or contexts.

Because weather is an important source of dynamic information available to IMTs during fire events, this study focuses on how fire weather informs fire manager tactical decision-

making. Questions consider which pieces of weather information are used by fire managers and how they are used. We ask these questions specifically as they relate to the tactical decision to attack a fire directly or indirectly in the transition from initial to extended attack.

2.2 Methods

2.2.1 Subjects

The data presented here come from a web-based survey sent to federal fire managers working for the United States Department of Agriculture (USDA) Forest Service. For this survey, we specifically targeted fire management officers (FMOs) (i.e., assistant fire management officers, forest fire management officers, etc.). To be an FMO, individuals need several years of operational firefighting experience and hold qualifications to serve as division supervisors, operations section chiefs, or incident commanders on IMTs. We developed our initial list of FMOs from internal email lists (n = 239) and augmented and corrected this list by contacting individual Forest Supervisors to check that our list was up to date for their forests (n = 708). After removing invalid emails, we had a final list of 669 potential respondents. Surveys were conducted over Sawtooth, a web-based survey and choice experiment platform (see Appendix A for survey instrument). 243 respondents, or 36% responded. After removing respondents who did not complete the choice experiment, the final sample included 182 respondents for an adjusted response rate of 27%. This response rate is in line with previous online surveys of federal fire managers, with response rates varying from 25 – 50% (e.g., Hand et al. 2015; Wibbenmeyer et al. 2012; Wilson et al. 2011)

2.2.2 Descriptive Measures

The survey included questions about how long participants had worked in fire and in their current job as well as their gender, education, and what role they served as most frequently on IMTs. Additionally, to control for other potential influences on decision-making beyond fire weather information, we asked respondents whether they perceive direct or indirect attack as riskier for firefighter safety using a bipolar 5-point scale ranging from “direct attack is much riskier” to “indirect attack is much riskier” where the middle point equals indifference. Additionally, we measured respondent confidence in weather models, specifically how frequently they believe wind, precipitation, relative humidity (RH), and general weather forecasts are accurate on a 4-point ordinal scale. To compare confidence across weather models, we conducted post-hoc pairwise t-tests with Bonferroni adjustments for multiple comparisons.

2.2.3 Choice Experiment Rationale and Description

The survey also included an embedded choice experiment. Choice experiments, or conjoint analyses, are frequently used to elicit consumer preferences. In natural resource management literature, these tools are often used to measure the willingness to pay for ecosystem services. Discrete choice experiments assume that people choosing between alternatives maximize their personal utility. In the context of fire management, maximizing personal utility is considered to align with maximizing optimal fire-management outcomes (Calkin et al., 2012). Choice experiments highlight which attributes are the most important factors influencing decision maker choices. Thus, choice experiments allow us to examine how different levels of a given attribute, such as the varying probability of wetting rain, influence which tactics fire managers believe are best for a fire. Choice experiments also allow comparisons of the relative importance

of different attributes, for example whether fire managers are more sensitive to changes in precipitation or changes in wind speed when making tactical decisions.

Before beginning the choice experiment, we provided all respondents with the same description of an ongoing wildfire event (see Figure 2.1 for a full description). We designed this introduction to be ambiguous such that it was not immediately clear whether direct or indirect attack was safer or more likely to succeed, and both direct and indirect attack were politically feasible and acceptable based on existing policy. There are substantial challenges in designing a wildfire scenario that is realistic in light of the real-world complexity associated with such decisions. Some simplification is required given the limitations posed by experimental research; however, we sought to develop a context for their later decision that included or controlled for the primary variables that influence decisions about direct versus indirect attack so we could assess the unique effect of weather information. To develop the background context or introduction as well as the critical attributes and levels to include, we sought feedback from several USDA Forest Service scientists with extensive experience working on these issues. We also conducted a focus group with FMOs from one USDA Forest Service region where scenarios were reviewed, discussed, and subsequently adjusted.

After reading the introduction, respondents were asked on a scale of 1 (strongly prefer direct attack) to 5 (strongly prefer indirect attack) to what extent they believed direct or indirect attack was preferable given the information provided. Respondents were then randomly assigned to one of two conditions (Table 2.1), in the first condition (n = 103), respondents were told the initial attack team had decided to indirectly attack the fire in the first 48 hours. Now that the respondent was arriving on the scene, they would choose whether to stick with indirect attack, or switch from indirect to direct attack. In the second condition (n = 79), respondents

were told the initial team had decided to directly attack the fire in the first 48 hours, and now that the respondent was arriving on the scene, they would choose whether to stick with direct attack or switch to indirect attack. In both conditions, we asked respondents to what extent they agreed with the initial attack team's decision on a scale of 1 (strongly disagree) to 5 (strongly disagree).

Figure 2. 1 Choice Experiment Scenario Introduction

Imagine the following event:

A lightning-ignited fire is burning in **mixed conifer** and has escaped initial attack and overwhelmed initial resources. The fire is currently **150 acres** and is being managed as a **Type 3 event** and **you are the most qualified individual** (for example, ICT3 or DIVS) arriving on the incident. **It is an average fire season in the area where the fire is occuring**, and you may or may not get more resources if you request them. Pictures of the general area have been provided below. You have requested short-term fire behavior analysis and a spot weather forecast. **You are 48 hours into the event**, it is early morning, the nearest primary care center is less than an hour away, and there have been no "incidents within the incident".

Your local **planning documents** allow you to **manage fire**. The **public** has mixed feelings; while **some dislike fire** and favor suppression, **others understand the ecological role of fire** and are more tolerant of non-suppression tactics. **The nearest community is ten miles away** from where the fire started.

The fire is burning in **moderate terrain with snag potential**. While there are areas to directly engage with an anchor point, weak trees may be present. The area of indirect attack features roads about a mile away and ridges between 0.5 – 1.5 miles away from the fire perimeter.

Pictures of the general area:

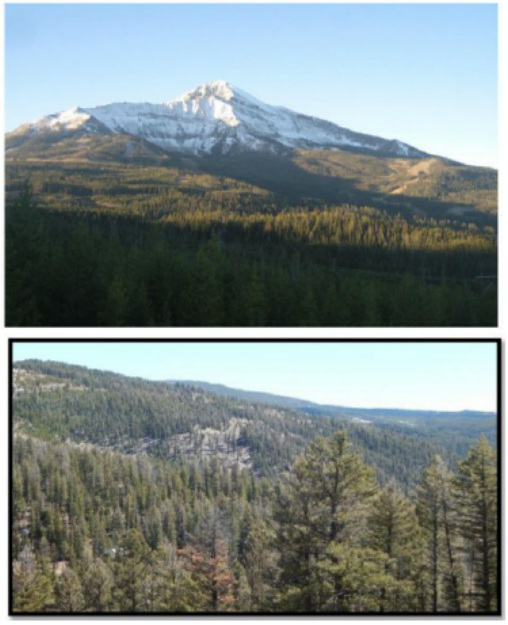


Table 2. 1 Description of each experimental condition

	Condition	
	Condition 1 (n=103)	**Condition 2 (n=79)**
Initial team strategy	Indirect	Direct
Choice experiment measured	Willingness to switch to **direct** attack	Willingness to switch to **indirect** attack
Interpretation of positive utility	Attribute level is more amenable to **direct** attack	Attribute level is more amenable to **indirect** attack
"NONE" alternative interpretation	Utility of a given alternative must exceed the utility of NONE for **switching to direct attack** to be preferable to the status quo	Utility of a given alternative must exceed the utility of NONE for **switching to indirect attack** to be preferable to the status quo

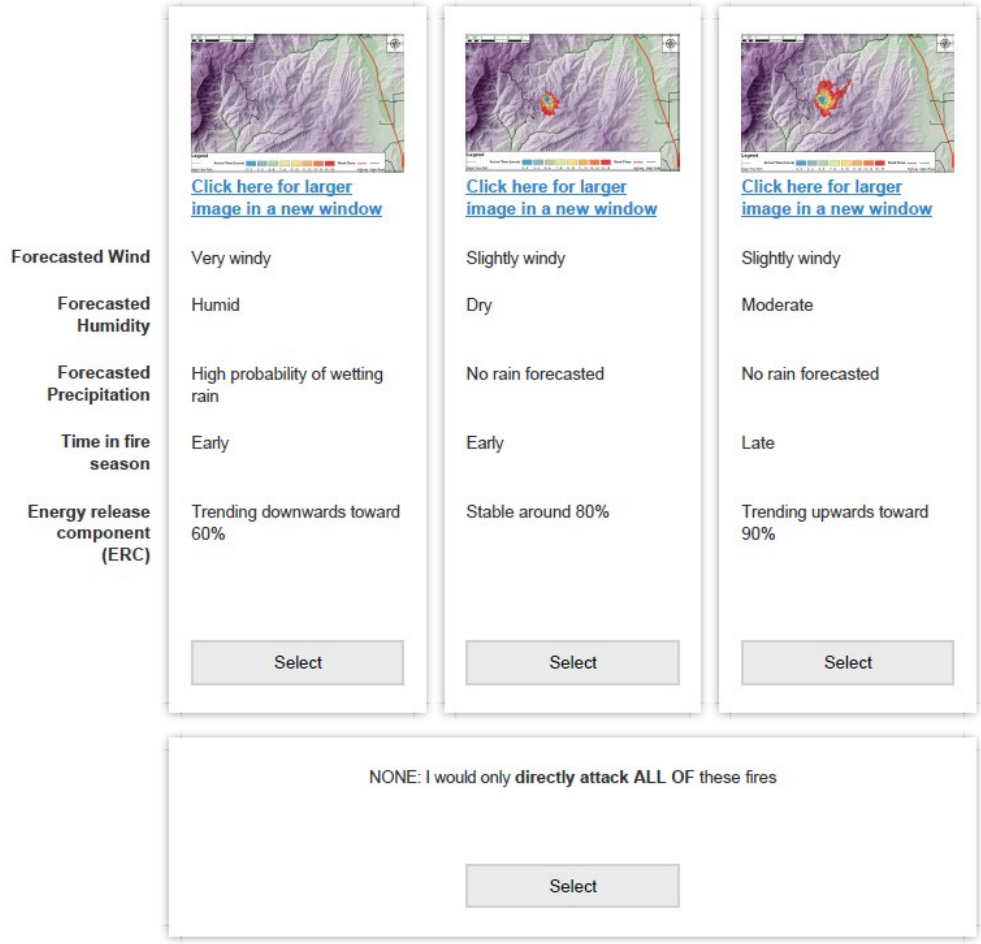
Respondents were then presented with nine choice sets, or nine opportunities to select a scenario where they would switch the strategy or indicate a preference for remaining with the current strategy. Each choice set contained three scenarios that varied across five attributes: energy release component (ERC), time in season, forecasted precipitation, forecasted relative humidity, and forecasted wind. The three weather attributes (precipitation, RH, and wind) were used to generate a map of potential fire spread for each scenario and this map was also provided to respondents. In each of the choice sets, respondents were instructed to examine the three scenarios and select the one for which they would most support switching the strategy, or to indicate they would continue with the initial team's strategy (labeled as "NONE" as they would not switch the strategy in any of the scenarios). All attributes and possible levels are summarized in Table 2.2. An example of a choice set respondents could see is provided in Figure 2.2. After the choice set, respondents were provided an open-ended box where they could describe what factors were the most important in influencing their decision. We coded

open-ended responses and calculated how frequently each factor was mentioned across the two conditions.

Table 2. 2 Summary of attributes and levels in choice experiment

Attribute	Attribute Levels		
Forecasted wind	Slightly windy	Windy	Very windy
Forecasted relative humidity	Humid	Moderate	Dry
Forecasted precipitation	No rain forecasted		High probability of wetting rain
Time in fire season	Early	Middle	Late
Energy release component	Trending downwards toward 60%	Stable around 80%	Trending upwards toward 90%

Figure 2. 2 Example Choice Set



2.2.4 Choice Experiment Analysis

We used Sawtooth Software SSI Web to conduct our online discrete choice experiment and determine both the necessary number of choice sets given the number of attributes and levels, as well as how the attribute levels would be assigned to each scenario within the choice set. Many choice experiments use a fixed orthogonal design to limit the total number of choice sets respondents must see to calculate unbiased coefficients. We used Sawtooth's balanced overlap method of randomized design. This method allows some pairs of attributes to co-occur, reducing the number of choice sets a respondent must complete without significant loss in

reliability (Sawtooth Software, 2017). In balanced overlap designs, respondents see each level of any given attribute an approximately equal number of times. Each level of each attribute may not appear an equal number of times, especially if attributes vary by how many levels they have (e.g., our precipitation attribute has two levels and our relative humidity attribute has three levels).

Choice experiments use probabilistic modeling to separate the overall utility of an alternative U_j into the observable factors V_j of a given alternative A and the unobservable factors ε_j. Here we are calculating the utility of each specific scenario in the choice set as the alternative. This random utility model is represented by the following equation.

$$U_j = V_j(A) + \varepsilon_j$$

We estimated our random utility model using hierarchical Bayesian (HB) analysis. HB analysis has two levels. The upper level assumes individual vectors of part-worths are described by a multivariate normal distribution. The lower level assumes that the probability that an individual selects a given scenario can be described by a logit model, where the utility of each scenario is the sum of the part-worths of its attribute levels (Johnson, 2000). HB iteratively calculates individual part-worths and average utilities for the sample to examine how respondents differ from sample averages. After thousands of calculations, the solution converges. Calculations after convergence are averaged to get part-worth utility coefficients. We report on two measures, the average part-worth utilities for each level of each attribute and the overall importance of each attribute. For each attribute, the sum of the part-worths of each level is zero. Consequently, negative part-worths do not necessarily reflect negative utility, but rather a smaller utility than positive part-worths. Overall importance is a study-specific measure

of how important a given attribute is compared to other attributes in the choice experiment. It is influenced by the range of the part-worth utilities of the attribute; the larger the range of part-worths for a given attribute, the more important it is. To calculate importance, the relative range of part-worth utility for each attribute for each respondent is calculated as a percent of the total range across attributes, and then averaged across respondents (Orme, 2010). Thus, the importance measures of all attributes sum to 100%, and measures of importance are ratio-scaled, which is to say an attribute with an importance of 50% is twice as important as an attribute with an importance of 25%. Therefore, in interpreting the results, the higher the utility score of a particular scenario, the more likely respondents are to switch from the default or initial attack decision.

2.3 Results

2.3.1 Respondents Demographics

Respondents were very experienced in fire management, on average serving 8 years in their current position and 24 years in fire management overall. Respondents' roles varied: 32% indicated they most frequently served as division supervisors, 26% as incident commanders (Type 1 – 3), 18% as operations section chiefs, and 24% in other roles, e.g., technical specialists, safety officers, and task force leaders. Most of our respondents (88%) identified as male and a majority (69%) had at least a bachelor's degree.

2.3.2 Risk perception and forecast reliability

The majority of respondents (56%) believed direct and indirect attack were equally risky for firefighter safety (Table 2.3). Respondents tended to have moderate to high confidence in all weather forecasts, indicating that forecasts were reliable 51 – 75% of the time (Table 2.3).

However, we did find that average confidence differed significantly across models (df = 3, *F = 16.003.* p < .001). Pairwise t-tests indicate that respondents have lower confidence in precipitation and wind forecasts than relative humidity or weather forecasts in general (p < .05) (Table 2.4).

Table 2. 3 Descriptive statistics of agency pressure, risk perception, and forecast reliability

Variable	Mean	Median	Range
Perceived risk of direct and indirect attack	2.94	3*	1 – 5
General forecast reliability	2.90	3**	1 – 4
Wind forecast reliability	2.65	3**	1 – 4
Precipitation forecast reliability	2.59	3**	1 – 4
Relative humidity forecast reliability	2.84	3**	1 – 4

Table 2. 4 Pairwise comparisons of average reliability of weather forecasts with Bonferroni Correction

Model (I)	Model (J)	Mean Difference (I – J)	Std. Error	Bonferroni Adj. p-value	95% Confidence Interval for Difference
General	Wind	0.256	0.0523	<.001	0.116, 0.396
	Precipitation	0.311	0.0523	<.001	0.171, 0.451
	Relative humidity	0.067	0.0513	1.00	-0.07, 0.204
Wind	Precipitation	0.055	0.0643	1.00	-0.117, 0.227
	Relative humidity	-0.189	0.0558	0.005	-0.338, -0.040
Precipitation	Relative humidity	-0.244	0.0618	<.001	-0.409, -0.079

2.3.3 Choice experiment introduction and initial attack decision

While we intended the initial choice experiment introduction to be ambiguous such that respondents would not automatically prefer direct or indirect attack, two-thirds (68%) of respondents believed indirect attack was at least somewhat more preferable than direct attack after reading the introduction ($\bar{x} = 3.73$). Later, when judging how much they agreed with the initial team's decision to either directly or indirectly attack the fire, respondents were more supportive of the initial team's decision to indirectly attack ($t = 4.8$, $p < .001$). Specifically, respondents who were told the initial team indirectly attacked the fire tended to agree with the initial team's decision ($\bar{x} = 4.03$), while respondents who were told the initial team directly attacked the fire neither agreed nor disagreed with the initial team's decision ($\bar{x} = 3.20$).

2.3.4 Choice experiment outcomes

2.3.4.1 Condition 1: Switching from indirect to direct attack

In this first condition, respondents chose whether to switch from indirect to direct attack. Seasonality was the most important attribute influencing this decision (average importance score = 37.40; see Table 2.5); indicated by the large range in the utility scores with being early in the season having the highest part-worth utility and being late in season having the lowest part-worth utility of all attributes and levels. The highest part-worth utility for early in the season indicates that respondents have a stronger preference to switch to direct attack when it is early versus middle or late in the season (Table 2.6). Wind was the second-most important attribute (average importance score = 19.31 indicating it is approximately half as important as seasonality), with respondents preferring to switch to direct attack when the forecasted wind was low (described as slightly windy) compared to when the forecasted wind was high (described as very windy). Precipitation was the third most important attribute

(average importance = 18.74). Respondents have a stronger preference for switching to direct attack when wetting rain is forecasted compared to no rain in the forecast. ERC was the fourth most important attribute (average importance = 16.15). Interestingly respondents did not have clear linear preferences with regards to ERC. Specifically, the highest value ERC, ERC trending upwards toward 90%, had the highest part-worth utility, but the medium value for ERC, ERC stable around 80%, had the lowest part-worth utility. Relative humidity was the least important attribute (average importance = 8.41), with respondents preferring to switch to direct attack when RH was high (described as humid) compared to when forecasted RH was low (described as dry).

These results indicate that the ideal conditions for switching to direct attack would be a fire with wetting rain, where conditions were humid and slightly windy, early in the season and with ERC trending towards 90% (sum of all part-worth utilities for that scenario = 180.04). This combination of weather factors suggests moderate fire behavior early in the fire season. Additionally, respondents indicated that they preferred to indirectly attack all three fires in 48% of all choice sets. The NONE scenario (meaning respondents would not switch to direct attack in any of the described cases) had a relatively high utility score (average part-worth utility = 154.9) and only some combinations of attributes led to scenarios that were viewed as preferable to indirect attack. For example, the scenario with the ideal conditions described above had a greater utility than the NONE scenario. However, if the same scenario occurred in the middle of the season or late in the season, it would not be preferable to the NONE scenario. Put another way, respondents were only willing to switch to direct attack for some combinations of attributes early in the season, otherwise they preferred to continue with indirect attack.

Table 2. 5 Importance of each attribute across choice experiments

Attribute	Condition 1: Indirect to direct attack		Condition 2: Direct to indirect attack	
	Average importances	Standard deviation	Average importances	Standard deviation
Precipitation	18.74	12.46	31.46	14.23
Relative humidity	8.41	3.42	10.97	4.97
Wind	19.31	7.71	12.44	5.42
Seasonality	37.40	12.85	23.15	16.35
Energy Release Component	16.15	7.50	21.97	8.69

Table 2. 6 Utility of each attribute across choice experiments

Average utilities of attribute levels (zero-centered diffs)		Condition 1: Indirect to direct attack		Condition 2: Direct to indirect attack	
		Average part-worth utilities	Standard deviation	Average part-worth utilities	Standard deviation
Forecasted precipitation	High probability of wetting rain	26.94	49.53	-63.83	58.40
	No rain forecasted	-26.94	49.53	63.83	58.40
Forecasted relative humidity	Humid	14.48	19.50	-21.41	24.567
	Moderate	-11.84	13.78	7.95	19.01
	Dry	-2.64	14.28	13.47	19.10
Forecasted wind	Slightly windy	44.90	15.57	-4.55	28.67
	Windy	-7.55	30.99	-15.18	18.29
	Very windy	-37.35	32.99	19.73	26.70

Time in fire season	Early season	75.50	38.00	-34.98	59.82
	Middle season	23.68	29.48	2.69	25.66
	Late season	-99.18	55.19	32.29	63.97
Energy release component	ERC trending downwards toward 60%	5.19	38.37	-20.83	51.62
	ERC stable around 80%	-23.41	21.06	2.63	29.15
	ERC trending upwards toward 90%	18.22	39.36	18.20	58.04
	NONE	154.96	216.88	-68.69	159.91

2.3.4.2 Condition 2: Switching from direct to indirect attack

Unlike the first condition, precipitation was the most important attribute (average importance = 31.46; see Table 2.5) when deciding whether to switch from direct to indirect attack. Specifically, a weather forecast with no chance of wetting rain had the highest utility while a forecast of wetting rain had the lowest utility, indicating a preference to switch to indirect attack when there was no rain in the forecast. Seasonality was the second most important attribute (average importance = 23.15) , where consistent with responses in the other condition, respondents preferred to switch to indirect attack later in the season. ERC was the third most important attribute (average importance = 21.97), primarily driven by the relatively low utility of ERC trending towards 60% compared to ERC stable at 80% or trending towards 90%. Wind was the fourth most important attribute (average importance = 12.45). For wind, respondents did not have clear linear preferences. Specifically, the highest value for forecasted wind (i.e., very windy) had the highest part-worth utility, but the medium value for forecasted wind (i.e., windy) had the lowest part-worth utility. This does not indicate a clear trend for when respondents preferred to switch to indirect attack. Relative humidity was the least important

attribute (average importance = 10.97). Respondents preferred to switch to indirect attack when forecasted RH was low (i.e., dry) compared to when forecasted RH was high (i.e., humid).

These results indicate that the ideal conditions to switch to indirect attack would be a fire with no rain forecasted, low humidity and high wind, late in the season with ERC trending towards 90% (sum of all part-worth utilities for that scenario = 147.52). This combination of weather and fuel factors suggests extreme fire behavior, with a higher chance of a season-ending event on the horizon. In 92% of the choice sets, respondents chose to switch to indirect attack for at least one of the described scenarios. The NONE scenario had a low utility (part-worth utility = -68.69), thus respondents preferred to stay with direct attack for only a few limited combinations of attributes. For example, respondents preferred the NONE option or preferred to stick with direct attack when there was forecasted rain, conditions were described as humid and windy, early in the season with the lowest ERC (sum of all part-worth utilities = -156.24 or the lowest-utility scenario). However, if the same scenario were presented but without rain forecasted, we would predict respondents would prefer to switch to indirect attack. Put another way, respondents were only willing to continue with direct attack for some scenarios where wetting rain was forecasted, otherwise they preferred to switch to indirect attack.

For some scenarios, respondents preferred the NONE alternative in both conditions, whether the decision was to switch to direct or indirect attack (Table 2.7). For example, for some scenarios where wetting rain was forecasted and it was not early in the season, respondents in both conditions preferred to continue with the initial strategy. It is unclear why fire managers preferred the default in these cases. For example, it may be that the relative gain in utility was not believed to be worth the cost of changing tactics, or it may be that the fire

managers did not have a preferred tactic in those circumstances and defaulted to the previous team's tactics.

Table 2. 7 Example choice sets

	Combination of attributes	Condition 1 utility	Condition 2 utility
Highest utility condition 1*	High probability wetting rain, humid, slightly windy, early season, ERC trending upwards toward 90%	180.04	-106.57
Lowest utility condition 2**	High probability wetting rain, humid, windy, early season, ERC trending downwards toward 60%	114.57	-156.23
Highest utility condition 2**	No rain forecasted, dry, very windy, late season, ERC trending upwards toward 90%	-147.89	147.51
Lowest utility condition 1*	No rain forecasted, moderate humidity, very windy, late season, ERC stable around 80%	-198.71	126.43
Status quo preferred	High probability of wetting rain, humid, slightly windy, middle season, ERC trending downwards toward 60%	115.19	-107.93
NONE alternative	-	154.96	-68.69

*Condition 1 refers to the decision to switch **from indirect to direct attack**

Conditions 2 refers to the decision to switch **from direct to indirect attack

2.3.4.3 Open-ended comments

95 respondents who evaluated whether to switch to direct attack and 69 respondents who evaluated whether to switch to indirect attack provided open-ended comments, ranging from a couple words to paragraphs on what factors were most important to them in their decision (Table 2.8). Regardless of condition, the most frequently mentioned factor was seasonality. Respondents then mentioned wind and ERC across conditions at similar rates, but

consistent with the choice experiment, more respondents mentioned rain when switching to indirect attack versus when switching to direct attack.

Table 2. 8 Summary of most frequently mentioned codes for respondents' open-ended answers on the most important decision factors in the choice experiment.

Code	**Condition 1: indirect to direct attack** (n=95)	**Condition 2: direct to indirect attack** (n=69)
Seasonality	47%	54%
Wind	28%	26%
Energy release component	16%	19%
Relative humidity	8%	8%
Precipitation	15%	27%
Firefighter safety	21%	11%
Fire behavior and size	11%	20%

2.4 Discussion

Our results have several implications for how weather information and forecast models can be communicated more effectively to support tactical decision-making. We consider two implications in greater detail. First, our results highlight the importance of considering how information is used in light of the potentially heuristic decision strategies of fire managers. Tools will be more effective when designed with the decision strategies of fire managers in mind, either by supporting heuristic-based decision-making or by debiasing and encouraging more deliberative decision-making. Second, our results point to possible areas of improvement for

weather forecast models that might improve confidence. Wind and precipitation forecasts merit particular attention, either by improving model accuracy directly, improving confidence in existing models, or both.

2.4.1 Supporting Heuristic versus Deliberative Decision-making

Weather information can be an important determinant of tactical decision-making and success in wildfire management (Countryman, 1972; Rapp et al., 2020). However, our results highlight that weather information may not be used or interpreted consistently across decision-makers. Rather, what information fire managers use and what they learn from it depends on the context; weather information does not exist in a vacuum. This is consistent with the concept of preference construction, i.e., the phenomenon where decision-makers do not have pre-defined, immutable preferences going into the decision-making process. Instead, decision-makers form their preferences "on the spot" in response to cues that are available throughout the decision process. As a result, preferences are not revealed but rather constructed (Gregory et al., 2012; Slovic, 1995). Specifically, our results show that the relative importance of a given piece of weather information may depend on prior decisions. For example, wind was the most important piece of weather information when switching to direct attack, but wind was less important when switching to indirect attack. The tactical decision made previously influenced how weather informed future tactical preferences. Similarly, we saw some situations where the tendency was to stick with the status quo, regardless of what the status quo decision was, which may suggest when the best decision is ambiguous, fire managers lean on previous decisions (Wilson et al., 2011). This is not necessarily a maladaptive or inefficient decision-making strategy if there are non-negligible costs to switching tactics, but the benefits of switching are unclear or uncertain.

While it is not clear from these results alone why the initial attack tactics shaped fire manager preferences, there are several theoretical explanations to consider. In the context of this experiment and in decision-making in the field, fire managers may be interpreting information holistically, or comparing it to previous experience rather than integrating and weighing information through a deliberative process (Drews et al., 2015; Klein, 2008). In that case, the initial team's decision is a piece of information in and of itself, as respondents compare the current scenario to previous experience where the initial attack team either directly or indirectly engaged the fire.

Further, individual pieces of information may not be considered separately but rather in light of each other. Indeed, in the context of weather, this is likely an adaptive and appropriate strategy where weather factors can be more than the sum of their parts and reach critical thresholds for extreme fire behavior (Young et al., 2019). Although examining interaction effects or non-linear thresholds was outside the scope of our study, it is worth exploring in the future to understand not only how weather components physically interact to create fire behavior, but how fire managers combine pieces of weather information to infer expected fire behavior and how this may influence their tactical decisions. For example, while more extreme projected fire behavior is related to fire managers ordering more resources, certain weather situations such as extremely high winds may pose unique risks or challenges that factor into tactical decision-making (Bayham et al., 2020).

The decision strategy that a fire manager chooses to use can make decision support and the provision of critical information more or less difficult. For example, decision-makers can use compensatory or non-compensatory decision strategies. Non-compensatory strategies do not deal directly with tradeoffs across attributes of a decision, while compensatory strategies do. A

non-compensatory strategy would consider each attribute separately (e.g., if rain is forecasted, directly attack the fire, otherwise, consider the wind forecast), whereas a compensatory strategy would consider each attribute in combination (e.g., consider the precipitation and wind forecast information in light of each other when deciding on a preferred strategy). Non-compensatory strategies may be more common and are challenging to address through utility-maximizing decision support tools (i.e., decision support tools that assume decision-makers are utility-maximizers and, therefore, seek to calculate the maximum utility of each possible alternative with the assumption that the highest utility alternative is the best or most preferred). For example, a fire manager may use the Trade-off Analysis Exercise risk management tool to clarify and consider trade-offs between risks to firefighters, the public, and identified values for several potential courses of action (Schultz et al., 2021). A compensatory decision-maker is willing to make tradeoffs between acceptable levels of risk across different values while a non-compensatory decision maker seeks to minimize risk to one value, regardless of how much that may put other values at risk. Because the non-compensatory decision-maker is not seeking to maximize utility, but rather maximize the value of one attribute (e.g., minimize risk to a particular value, only attack directly if it is raining, etc.), utility-maximizing decision support tools may be less useful (Payne et al., 1993; Retief et al., 2013). Indeed, utility-maximizing decision support tools may be the least trusted where they are the most needed, for decisions that include painful or undesirable tradeoffs in which decision-makers have an incentive to ignore or deny the tradeoffs and make non-compensatory decisions (Beattie & Barlas, 2001).(Payne et al., 1993; Retief et al., 2013)(Beattie & Barlas, 2001)

Because fire managers must make time-constrained decisions with considerable risk and uncertainty (Thompson, Rodríguez y Silva, et al., 2017), it may be important to consider fire

managers as adaptive decision-makers in the context of tactical decision-making. Adaptive decision-makers must make tradeoffs between accuracy and effort when choosing decision strategies (Payne et al., 1993). In other words, they might choose a more effortful strategy (i.e., a compensatory and tradeoff focused strategy) to ensure a more accurate decision when the stakes are high but may do the opposite when the stakes are low. As their goals shift over the course of a fire, the same piece of information may be used in more deliberative or heuristic ways as the need for accuracy versus effort shifts. For example, when a fire first ignites and the probability of containment is high, precipitation forecasts may be used heuristically to quickly determine what resources should be sent to respond to an ignition. Later during extended attack when it is clear the fire will not be easily contained, precipitation may be just one piece of information weighed against a host of other factors (e.g., current wind conditions, resources available, etc.). Further, even in the context of one decision, fire managers may shift between decision-making strategies over time. This may occur when the decision context is uncertain and a different strategy seems more appropriate as information about possible alternatives is uncovered (Mintz, 2004; Mintz et al., 1997).

These results have important implications for the design and evaluation of decision support tools for operational personnel. Understanding the impact of decision support tools on fire outcomes is difficult because the information these tools provide is only one consideration among many for fire managers (Canton-Thompson et al., 2008; Rapp et al., 2020). During pre-fire planning, decision support tools can help decision makers make more informed and defensible decisions as they consider information in a collaborative and deliberative setting (Thompson et al., 2020). Successful decision support prior to a fire igniting may improve tactical decisions and outcomes in two ways. First, it can clarify objectives and goals for an area

including what role fire may play on that landscape should one ignite. Second, it can provide insight into the relative ease of containment of a fire based on the climate, topography, and fuels (O'Connor et al., 2016; Wei et al., 2018). However, during a wildfire event, tactical decisions made in response to changing conditions may be more time-constrained and decision makers may have fewer resources to dedicate to systematic decision-making, or the type of compensatory decision making intended to be supported by most existing tools.

While previous researchers have highlighted the types of information necessary for an operations-focused decision support tool (Dunn et al., 2017), results here emphasize that decision support tools should be designed and evaluated with the decision strategies used by fire managers in mind. For example, fire managers may consider some weather information more deliberatively or heuristically based on how it influences fire behavior. Weather conditions have both a direct and indirect impact on wildfires. For example, wind speed directly influences fire behavior by providing additional oxygen to the combustion zone and also by improving convective heat transfer to un-burned fuel ahead of the flaming front; therefore, increases in wind speed directly cause fires to spread faster and with higher intensity (Werth et al., 2011). Thus, all else equal, information on wind forecasts may be easier to analyze deliberatively given its incremental and direct effect on fire behavior. In comparison, other weather variations, such as temperature, humidity, and rainfall, indirectly influence fire behavior by their effects on fuel moisture content. Fire spread is determined by a simple energy balance: heat is used to either raise the temperature of adjacent fuels or it is used to evaporate water within that fuel. Variations in weather can either wet or dry fuels depending on the gradient between the fuel and air in the boundary layer around the fuel and these fuel moisture fluctuations can slow or accelerate fire spread. Thus, humidity and temperature have an indirect and incremental effect

on fire behavior and may be neglected as information when making decisions rapidly. In comparison, rainfall has the strongest and most direct impact on these fuel moisture variations because it can quickly saturate fuels as well as leave additional water on the surface of the fuels. The strong influence of precipitation on fire behavior leads to a discrete and relatively concrete reduction in fire behavior, making it a useful indicator for heuristic-based decision-making, while wind, temperature and humidity variations are more incremental and gradual. (Werth et al., 2011)

With that in mind, decision support tools can be designed to support compensatory or non-compensatory decision-making depending on how they frame and provide weather information. Importantly, fire managers cannot be neatly demarcated as either compensatory or non-compensatory, but rather, fire managers likely change and adapt their decision-making strategy depending on the importance of the decision and the time constraints they face. Thus, it is may be helpful to provide decision-makers with a variety of tools or sources of information they can choose from based on their capacity to make deliberative versus heuristic decisions. For example, tools for compensatory decision-makers should seek to simplify and summarize information while tools for non-compensatory decision-makers should seek to reduce the arbitrariness of cutoff levels or decision thresholds (e.g., at what change of precipitation do fire managers act as if it will rain, at what ERC do fire managers switch to direct attack) (Cook, 1993). In the case of previous decisions having undue influence on future planning, or the effects of anchoring to previous strategies and insufficiently adapting to new weather information, decision support tools should incorporate things like “consider the opposite” (Hirt & Markman, 1995). To consider the opposite, decision support tools ask the decision maker to consider if

their decision would change with a different status quo in place, and if so, why, as a means of balancing out any effect of a particular preexisting strategy.

2.4.2 Improving Confidence in and Use of Fire Weather Forecasts

Our results also provide insight into what conditions fire managers find most appropriate for direct and indirect attack. Broadly speaking, fire managers preferred to directly attack fires occurring early in the season with mild fire behavior but preferred indirect attack on fires occurring late in the season with extreme fire behavior. For some fires occurring in the early or middle of fire season where it is not raining, fire managers prefer to continue with the status quo, regardless of what it is. Fire managers were more sensitive to wind when switching to direct attack and more sensitive to precipitation when switching to indirect attack. Although the importance of different pieces of weather information varied in their influence on decision-making depending on the prior decision, our results still point to several practical needs when it comes to improving the weather information available to support decisions.

First, wind and precipitation were the most important pieces of weather information for decision-making yet respondents expressed lower confidence in the reliability of wind and precipitation forecasts. Thus, we suggest prioritizing efforts to improve the forecast accuracy where possible for these variables and increase confidence in the resulting forecast as appropriate. Typical fire weather forecasts are derived from the National Digital Forecast Database (NDFD) which are produced continuously across the United States by the US National Weather Service (Glahn & Ruth, 2003). A recent study has shown that the NDFD consistently underpredicts windspeeds when the winds are stronger than about 4 m/s (~9 mi/hr) (Page et al., 2018). Winds are particularly difficult to forecast due in part to local terrain influences and extensive work is ongoing to improve wind forecasts in complex terrain. Models that downscale

wind forecasts to correct for terrain influences, such as WindNinja (Wagenbrenner et al., 2016), show promise in improving local-scale wind forecasts.

Quantitative precipitation forecasts provided to wildland fire decision-makers are commonly derived from the NDFD and they are often modified by forecasters prior to issuance. However, investigators are continually exploring ways to improve precipitation forecast skill and spatial resolution using models such as the High Resolution Rapid Refresh (HRRR) (Benjamin et al., 2016). Continual improvements to the HRRR model physics and data assimilation show promise in improving precipitation forecasts over the next 18 hours (Bytheway et al., 2017). This interval generally conforms to an operational period for wildland fire operations. Other improvements to precipitation forecasts, such as ensembling, can provide uncertainty estimates of forecast that may also be useful for decision makers. Ultimately, given the importance of precipitation forecasts on decision-making, any efforts to improve skill or characterize uncertainty in precipitation forecasting will likely influence wildfire outcomes.

That said, improving model accuracy may not be sufficient on its own. While a certain threshold of accuracy and quality is necessary for model forecasts to have value to decision-makers, model quality is multi-faceted and not the same as the utility of a model to decision-makers (Murphy, 1993). While it would be reasonable to expect some correlation between accuracy and confidence in wind and precipitation forecasts, it is not a given that improvements in forecast accuracy will automatically lead to increased confidence. Thus, distinct efforts may be necessary to improve confidence in the models. These efforts could be informed by better understanding what aspects of the model lead stakeholders to use or ignore the resulting forecast. For example, in some cases personnel may be resistant to using models due to cultural ideas surrounding technology and models (Noble & Paveglio, 2020; Rapp et al., 2020). In those

cases, it may be more fruitful or even necessary to focus on changing how users relate using models and being competent at their jobs. In other cases, stakeholders and users may be disconnected from the development process for models, and communicating or demonstrating improvements may be helpful. In other cases still, the problem may not be with the models, but the perceived competence of the modelers (Noble & Paveglio, 2020; Rapp et al., 2020). In these instances, investing additional resources and attention towards training modelers and establishing relationships between modelers and end users may contribute to improving confidence in the resulting forecasts.

Seasonality was the most important non-weather-related attribute across conditions, with roughly half of respondents explicitly highlighting it as an important decision criteria in the open-ended response. Across both conditions, respondents preferred direct attack early in the season and indirect attack later. Although direct and indirect attack can be used on all fires regardless of the over-arching strategy, this preference appears borne out by the data which suggests that a greater proportion of fires are managed for suppression early in the season while the proportion being managed for other reasons increases later in the season (Young et al., 2020). In terms of tactics and strategy, the decision space of fire managers is likely larger later in the season as seasonal changes associated with the onset of autumn are likely to aid containment and reduce the severity of fire behavior. Additionally, fire managers may be able to justify using more resources to manage or indirectly attack a fire later in the season because these resources are less likely to be needed on a later fire during the same fire season. A key follow-up question is therefore how does weather information interpretation change over time? For example, while wind may be an important driver of fire manager decision-making regardless of the time of year, the interpretation of precipitation may depend on the time in season, where

precipitation earlier in the season may have less of an impact (or indeed may make fires worse through lightning strikes) but late-season precipitation may signal a season-ending event. Similarly, weather information may vary in importance over the course of a fire event. This work examines a pivotal moment in fire management, when fires transition from initial to extended attack, but other key decision points are worth considering, such as the decision to manage for resource benefit or suppression. Indeed, as more forests utilize pre-identified operation control points, it will be important to understand how weather shapes which control points are selected and what tactics are used. It is worth exploring in greater detail how fire managers personally understand and estimate wind, rainfall, humidity, and other fire behavior drivers and thus how information on these drivers influences perception of fire behavior over the course of events and seasons (i.e., to what extent do fire managers' mental models of the effect of fire weather conditions on fire behavior mimic actual fire behavior model predictions?).

2.5 Conclusion

Considerable effort has been made to support risk-based strategic decision-making for fire managers. To that end, many tools exist to provide information and structure decision-making. While some of those tools can be used at the tactical level, tactical decision makers may rely on and use different sources of information, especially weather. Weather plays a critical role in fire behavior and subsequently an important role in tactical decision-making and success. Understanding how fire managers use weather information to make tactical decisions is key to providing effective decision support. While weather information does indeed influence decisions, this information is not consumed in a vacuum; fire managers interpret it in light of previous tactics made by other actors. When designing operational decision support tools, it will be important to consider not only what information fire managers seek out and use, but how

they use it, as decision strategies, deliberative, heuristic, or otherwise, will shape tactical decisions and their consequences. Consequently, rather than simply providing information, decision support tools should also actively debias for things like insufficient adjustment to new information, for example by encouraging fire managers to imagine how their decisions might be different under a different status quo. Additionally, our results suggest opportunities for improvement and further study. Between wind, precipitation, and humidity forecasts, wind and precipitation were the biggest driver behind switching operational tactics, yet fire managers were less confident in wind and precipitation forecasts than weather forecasts in general. Improving or communicating forecast reliability may facilitate more risk-informed outcomes on fires by influencing what information fire managers attend to, and how much weight they give that information.

Chapter 3. Factors that contribute to trustworthiness across levels of authority in wildland fire incident management teams (published in *International Journal of Disaster Risk Reduction*)

3.1 Introduction

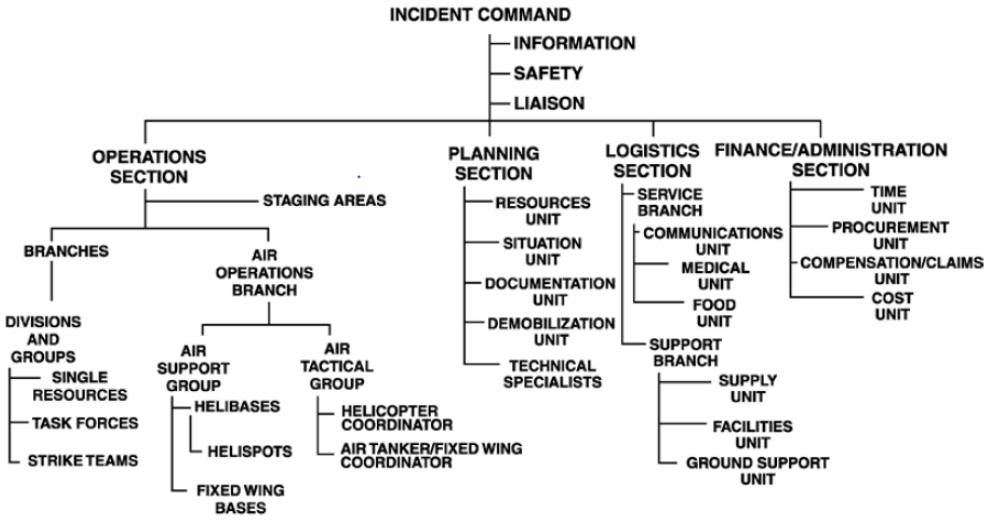
3.1.1 The Social Dynamics of Incident Management Teams

Wildfire is a vexing environmental problem. Uncontrolled wildfires pose a danger to lives, property, and ecosystems. However, fire is a key part of many fire-adapted ecosystems and aggressive suppression degrades these ecosystems (Dale, 2006) and increases the risk of catastrophic wildfire in the long-run (Calkin et al., 2015). Modern fire management is then challenged, not only by fuel build-up from a legacy of fire suppression (Calkin et al., 2015), but also climate change (Westerling, 2016; Westerling et al., 2006), and the expansion of the wildland urban interface in fire-prone areas (Radeloff et al., 2018; Theobald & Romme, 2007). In the United States, how wildfires are managed, from initial attack to mop-up, is dictated by the Incident Command System (ICS). The ICS is the mandatory organizational structure for all emergency management, including wildfire management (Jensen & Thompson, 2016). The ICS is designed to be flexible and scalable to apply to any emergency regardless of the size. Limited research has examined the effectiveness of the ICS as an organizing principle and this research has not been conclusive (see Jensen and Waugh 2014; Jensen and Thompson 2016 for reviews). For example, one case study suggests the incident command system both increases inter-organizational trust and reduces the need for it (Moynihan, 2008).

The ICS dictates the structure and hierarchy of the personnel addressing the hazard incident, the incident management team (IMT) (National Wildfire Coordinating Group, 2013). An IMT is headed by an incident commander, who operates as the liaison to relevant stakeholders and manages the overall IMT. Generally, the IMT is given discretion to make tactical decisions about the operational actions to be taken, including resource placement and tactics, to achieve the broader strategic goals (Taber et al., 2013). The effectiveness of IMTs is dependent on proper functioning at the individual, section, team, and inter-team level. IMTs must effectively coordinate with host agencies as well as local responders and stakeholders all of whom must agree on definitions of success (Curnin et al., 2015) in order to achieve the collective goals of the fire in line with each group's policies and priorities (Power, 2018). At the team level, sections tasked with separate but interdependent responsibilities need to communicate and coordinate with each other. IMTs are divided into different sections and depending on the complexity and size of the fire, this may include operations, planning, logistics, finance, information, safety, and liaison, each headed by a respective chief (National Wildfire Coordinating Group, 2013). All sections of the IMT need to coordinate effectively with each other to successfully manage fires (McLennan et al., 2006), but the operations section is particularly important for incident success (Owen et al., 2016). The operations section includes on-the-ground firefighters and air resources who do the physical work of fire suppression and management. Depending on the size of the incident, the operations section can include multiple layers of supervision (Figure 3.1). Within each section, the IMT is further divided and hierarchically arranged with each unit reporting to their respective chief, supervisor, or leader. At all levels, IMTs follow the organizing principle of span of control, which relates to the number of subordinates a supervisor can effectively and efficiently manage. Ideally, each supervisor should manage 3 to 7 subordinates, and wildland

fire incident management guidelines recommend a ratio of one supervisor for every five direct reports (National Wildfire Coordinating Group, 2013).

Figure 3. 1 The incident command system, adapted from the 2013 Wildland Fire Incident Management Field Guide (National Wildfire Coordinating Group, 2013).



A variety of technical and non-technical skills are needed for effective incident management (Hayes et al., 2021). For leaders in particular, a series of studies by Waldron and colleagues highlights three factors of wildland fire leadership: 1) competent decision-making, 2) integrity (including perceived trustworthiness), and 3) being personally genuine (Waldron et al., 2015; Waldron & Schary, 2019). Similarly, according to their peers, excellent incident commanders are not only operationally competent but have strong interpersonal and communication skills (Boyatzis et al., 2017). At the team level, a recurring theme in IMT effectiveness is team metacognition and the maintenance of shared mental models. As IMTs become larger, it is more difficult for individuals to hold the emergent properties of the team in

their mind, and the hierarchical division of labor of the IMT can exacerbate these issues (Bigley & Roberts, 2001). Disconnects, identified as singular instances of disparity between the mental models of individuals on IMTs, can lead to breakdowns that cause IMTs to stop functioning effectively (Bearman et al., 2015). Thus, sense-making and communication skills are needed during escalation and incident management (Hayes et al., 2021) because maintaining a shared understanding of the fire requires continuous and effective communication across levels of authority (Jahn & Black, 2017).

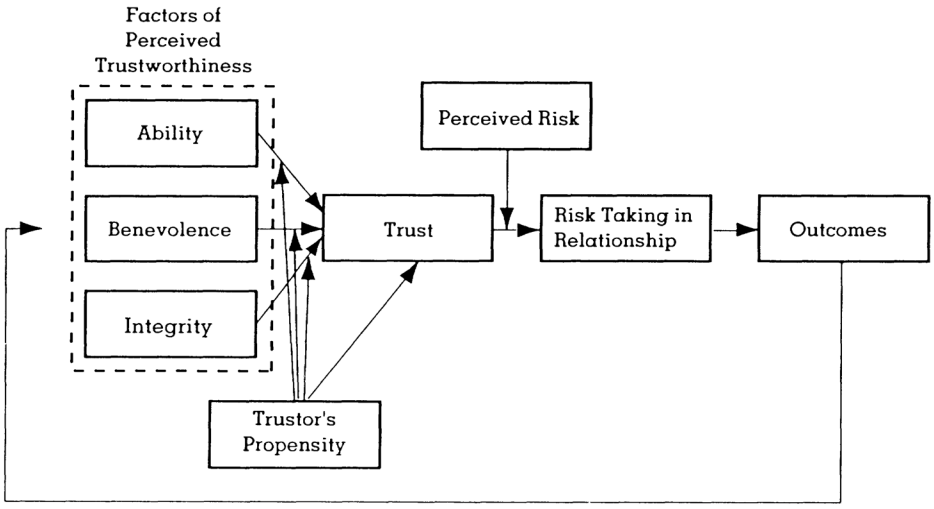
A key goal of communication is the consistent flow of information across team members. An important factor in how fire managers interpret and use information is their level of trust in the information source: fire managers are more likely to believe and use information from trusted sources (McLennan et al., 2006; Rapp et al., 2020). This is in line with the use of trust as a heuristic, a shorthand decision rule meant to quickly evaluate the quality, importance, and relevance of knowledge (McEvily et al., 2003). While heuristics can allow decision makers to make "good enough" decisions rapidly, they can also lead to biased decision making if the heuristic is poorly calibrated for the decision environment (Gerd, 2008; Kahneman & Klein, 2009). The importance of trust between team members is highlighted in several studies of incident management teams and the broader incident command system (Bigley & Roberts, 2001; Hayes, 2014; Jensen & Thompson, 2016; Moynihan, 2008). Although researchers seem to agree trust is important, it is not clear what characteristics IMT members look for in each other when evaluating trustworthiness However, lessons can be learned from organizational studies of trust in teams.

3.1.2 Models of Trust in Organizational Psychology

Trust is a critical component of working in teams. Trust in work teams and supervisors is associated with greater information and knowledge sharing (Chowdhury, 2005) and better team performance (de Jong et al., 2016). Trust is generally defined as the willingness to be vulnerable to the actions of the trustee because of a belief that the trustee will perform a particular action (Mayer et al., 1995; Rousseau et al., 1998). However, one study in emergency management adopted a slightly different perspectives, including confidence in their definition in addition to positive expectations (Hayes, 2014). Commonly, trust is conceptualized with two dimensions, a cognitive dimension formed earlier in the relationship based on a calculative assessment of an individual's trustworthiness, and an affective dimension formed later based on positive affective evaluations of the trustee (Jones & Shah, 2016; McAllister, 1995).

One of the most commonly used models is the integrative model of organizational trust which theorizes that trust is a behavioral intention influenced by the trustor's propensity to trust and the trustee's trustworthiness, based on their ability, benevolence, and integrity (Colquitt et al., 2007; Mayer et al., 1995) (Figure 3.2). According to Mayer and colleagues (1995), ability refers to the context-specific skills, competencies and characteristics of the trustee that enable them to sufficiently complete the action, benevolence is the extent to which the trustee wants to do good to the trustor specifically regardless of any egocentric motive or incentive, and integrity refers to the belief that the trustee adheres to an acceptable set of principles and values.

Figure 3. 2 The integrative model of organizational trust, adapted from Mayer, Davis, and Schoorman 1995. (Mayer et al., 1995)



The integrative model of organizational trust has been used in a variety of contexts, including studies on structural firefighters and public perception of fire managers (Colquitt et al., 2011; Sharp et al., 2013), but it is not without criticism. Some researchers have argued the tripartite model of trustworthiness as a function of ability, benevolence, and integrity is incomplete and that there is utility in assessing whether additional antecedents of trustworthiness are relevant to different types of teams (Breuer et al., 2019). For example, in their review, Dietz and Den Hartog (2006) argue that predictability, defined as the extent to which a trustee has consistent and regular behavior, is a key component of trustworthiness. Additionally, existing theories and frameworks for trust in typical organizational teams may not be applicable to teams that work with serious risks to personal safety (e.g., military teams) (Brandebo et al., 2013). Others have called for greater analysis of trust among team members who work in environments involving high degrees of uncertainty, vulnerability, or stress (Mishra & Mishra, 2013). In one study on small military teams working in high risk environments, authors divided trustworthiness into person-based factors (e.g., personal characteristics such as ability and interactive factors such as shared goals) and category-based factors (e.g., attained

rank, culture or gender stereotypes) (Adams & Webb, 2003). In addition to working in a context marked by high risk and dynamic conditions (Thompson, Rodríguez y Silva, et al., 2017), IMT members are embedded in a hierarchy, with many team members acting as supervisors and subordinates simultaneously. Consequently, it is important to assess how level of authority influences what characteristics IMT members seek out in trustees.

3.1.3 Felt Trust

Trust is often examined as a unidirectional phenomenon with a trustor and trustee (Fulmer & Gelfand, 2012; Krasikova & LeBreton, 2012). However, researchers have long considered trust as a bidirectional and emergent dyadic phenomenon (Blau, 1964; Mayer et al., 1995). Thus, in a trust dyad, members both trust and are trusted. The extent to which an individual believes they are trusted and perceived as trustworthy is their felt trust and felt trustworthiness (Brower et al., 2000; Dirks & Skarlicki, 2009). Compared to trust, considerably less is known about the process and outcomes of feeling trusted by a person, team, or organization. Importantly, trust in someone and feeling trusted by that same person are not necessarily related; there is little reason to believe two people in a dyad must have the same level of trust or agree on the quality of the relationship (Brower et al., 2000). However, this is not to say that trust in an individual does not influence felt trust from them. Felt trust may be decided through a heuristic of assumed reciprocity rather than through directly observed trusting behavior (Campagna et al., 2020). In the context of the studies conducted by Campagna et al., (2020), supervisors evaluate felt trust from subordinates not based on observing subordinates engaging in trusting behavior, but by evaluating how much they trust their subordinates and assuming that trust is reciprocated.

Other evidence suggests individuals use different criteria to determine whether to trust someone and whether they believe that person trusts them. While trust is expressed by relying on and disclosing information to the trustee (Breuer et al., 2019; van der Werff & Buckley, 2017; Zand, 1972), studies on felt trust suggest disclosure may be less important than reliance for feeling trusted (Lau et al., 2014; Zheng et al., 2019), although it is unclear to what extent this is context- or task-dependent. In studies on felt trustworthiness, researchers have assumed a reflexive form of the integrative model is appropriate (i.e., felt trustworthiness is determined by felt ability, felt benevolence, and felt integrity) (e.g., Bernstrøm & Svare, 2017; Lester & Brower, 2003). However, the same limitations that apply to the integrative model of trust and IMTs also apply to felt trust and felt trustworthiness.

3.1.4 The Present Research

Trust is important for IMT success, but it is not clear how IMT members evaluate trustworthiness of individual team members. Because they are both supervisor and subordinate, operational IMT members offer a unique opportunity to examine how individuals assess trust across levels of authority and whether they hold themselves to the same standards they hold their trustees. This leads to the following research questions:

RQ1: What characteristics do operational IMT members look for in trustworthy supervisors and subordinates?

RQ2: Are those the same characteristics they believe their subordinates and supervisors look for in them?

3.2 Methods

We conducted 27 semi-structured interviews exploring the psychological antecedents of trust and felt trust. Fire managers who served on incident management teams were interviewed about their experiences developing and receiving trust from their direct reports and supervisors. Respondents were largely operational, including division supervisors, operation section chiefs, and incident commanders, although a few respondents were in the planning section, and many had diverse qualifications to serve in many roles in the IMT. Most respondents had both direct reports and supervisors who worked on the incident management team, with some exceptions. For example, four respondents primarily served as incident commanders. Although incident commanders do technically report to the line officer, line officers are excluded from the present analysis because of the unique relationship between the line officer and the IMT. Line officers are employees of the home agency where the fire takes place and are not members of the IMT. Typically, line officers are public land supervisors who manage the day-to-day operations of a public land unit. Consequently, they may or may not have wildland fire training. Thus, in this analysis, incident commanders were treated as if they do not have a supervisor. In addition, one respondent in the planning section did not have direct reports.

We identified the initial list of potential participants from the study teams' fire science network contacts. We solicited additional names using a snowball approach. Specifically, at the conclusion of each interview, we asked participants to recommend relevant personnel for further interviews. Using a snowball approach may introduce bias because interviewees may recommend others with similar views to their own. However, snowball sampling also allows identification of respondents who may otherwise be overlooked. Between May and September

of 2020, we completed 27 remote interviews.[1] We continued interviewing new respondents until no new topics were emerging representing saturation. Our sample size is in line with previous qualitative work interviewing incident management team members, which include sample sizes ranging from 15 to 48 respondents (Boyatzis et al., 2017; Canton-Thompson et al., 2008; Owen et al., 2016; Rapp et al., 2020). Interviews lasted between 40 and 117 minutes, with most interviews lasting about an hour.

We used a set of guiding questions during the interviews but conversation was not confined to those questions and was allowed to proceed organically (Patton, 2002). During the interviews, respondents were asked what characteristics they looked for in trustworthy supervisors and direct reports, what they believed their supervisors and direct reports were looking for in them when assessing trustworthiness, and example anecdotes of experiences trusting, distrusting, being trusted, or being distrusted by their team members (see Appendix B for interview protocol). Questions focused on trusting relationships with direct reports and the respondent's immediate supervisor, rather than "team members", which could be construed by respondents in a variety of ways and refer to a much wider variety of personnel, including personnel from other sections of the IMT or personnel at the same level of authority and working parallel to the respondent. We transcribed recordings of the interviews and analyzed these recordings for themes using the data analysis software *MaxQDA*.

Analysis looked at the psychological antecedents of four kinds of trust. 1. Felt trust from subordinates (i.e., what do you think your direct reports are looking for in a trustworthy supervisor), 2. Trust in subordinates (i.e., what are you looking for in a trustworthy direct

[1] The researchers conducted 29 interviews in total, however, 2 interviews were rejected due to poor internet connections and unusable audio files.

report), 3. Felt trust from supervisors (i.e., what do you think your supervisors are looking for in a trustworthy direct report) and 4. Trust in supervisors (i.e., what are you looking for in a trustworthy supervisor). We used a multi-step coding procedure guided by existing models but left open for emergent themes (Creswell & Poth, 2018; Rubin & Rubin, 2005; Saldana, 2010). In the first pass, interviews were descriptively coded using an open-coding method. In the second pass, a preliminary codebook was developed based on the open codes and current theory. In the third pass, two coders coded 5 interviews together. The two researchers reached 76% intercoder reliability and greater than 99% intercoder agreement. Intercoder reliability requires coders to operate in isolation from each other and measures the percentage of matching codes. Intercoder agreement requires coders to reconcile any discrepancies through discussion and measures final agreement after arbitration (see Campbell, Quincy, Osserman, & Pedersen, 2013 for a discussion of intercoder agreement). After the intercoder reliability check, one author coded the remaining interviews.

3.3 Results

Ability, benevolence, integrity, and predictability emerged as key components of trustworthiness in incident management teams. They are also important for felt trustworthiness. Gender also plays an important role in how team members give and receive trust. There is limited evidence that the psychological antecedents of felt trust differ from trust with the same trustee (Table 3.1). For example, if respondents valued a characteristic in their supervisors (supervisor trustworthiness), they generally believed their direct reports valued it in them (subordinate felt trustworthiness). Similarly, if respondents valued a characteristic in their subordinates (subordinate trustworthiness), they generally believed their supervisors valued it in them (supervisor felt trustworthiness). However, in general, integrity seems to be more

important for trusting rather than feeling trusted, and there are some important differences in the characteristics that make a trustworthy supervisor (supervisor trustworthiness and subordinate felt trustworthiness) and a trustworthy subordinate (subordinate trustworthiness and supervisor felt trustworthiness).

Table 3. 1 Percentage of applicable respondents who described each component of trustworthiness (n = 27).

	Ability	Benevolence	Integrity	Predictability	Gender
Trust in Subordinates*	96%	15%	62%	27%	12%
Felt Trust from Subordinates*	92%	77%	46%	35%	15%
Trust in Supervisors**	91%	74%	74%	30%	22%
Felt Trust from Supervisors**	87%	17%	30%	26%	26%

*26 respondents had applicable subordinates

**23 respondents had applicable supervisors.

3.3.1 Ability

Ability is one of the three theorized components of trustworthiness according to the integrative model of organizational trust (Mayer et al., 1995) and an important component of cognitive trust (McAllister, 1995). According to the model, ability is the group of skills, competencies, and characteristics that enable a party to have influence within some specific domain. Across referents, ability was the most frequently mentioned characteristic that contributed to both trust and felt trust; ability was mentioned by nearly every respondent for each of the four types of trust, and 100% of respondents mentioned ability for at least one trust referent (Table 3.2).

Table 3. 2 Summary of characteristics important for ability.

Characteristic	Trust in Subordinates (n = 25)	Felt Trust from Subordinates (n = 24)	Trust in Supervisors (n = 21)	Felt Trust from Supervisors (n = 20)
Symbols of competence used during size-up	++*	++	+	++
Operationally sound decision-making	+++	+++	++	+++
Leadership	++	+++	++	++
Communication skills	++	+++	+++	+++

* "+" = one-third or fewer of respondents who discussed ability described it with the characteristic, "++" = more than one-third and up to two-thirds of respondents who discussed ability described it with the characteristic. "+++" = more than two-thirds of respondents who discussed ability described it with the characteristic.

3.3.1.1 Initial impressions of competence and baseline qualifications

Respondents explained that when arriving on a fire there is an initial proving period where individuals try to rapidly assess each other's competence, skills, and abilities. During this sizing-up period, key pieces of information could be used to rapidly assess ability. Regardless of the trust referent, one of the main ways a trustee could quickly communicate their ability and competence was through accepted symbols or signals of skill and ability. For example, in general, hotshots (the most skilled form of hand crew) were assumed to be more competent than other types of crews, especially contract crews. Therefore, a fire manager who had served as a hotshot previously was often given more credibility automatically. Respondents indicated they would either wear or look for hotshot clothing, such as a patch or belt buckle. Other physical signs could also be used to infer ability, such as being physically strong or matching the stereotypical firefighter presence: tall, masculine, and stoic.

Also across referents, the more years and diversity of experiences an individual had in their position, the more competent they were assumed to be, with some caveats. Because of the nature of fire activity, specific regions of the United States may carry a stigma; respondents indicated being from the Midwest or South may be a liability for perceived competence compared to being from the West or Southwest. As well, all else equal, people are assumed to be more competent in their home region and less skilled outside it.

The strongest difference across trust referents with regards to ability was whether simply being formally qualified for a position conferred any assumed competence. Respondents indicated that they assumed their direct reports were competent because they were qualified for their job. The act of going through a task book and receiving the designation of "division supervisor", for example, was often enough for respondents to believe their direct report was a competent division supervisor. However, that implicit trust was generally not extended to any other trust referent. For example, respondents generally assumed their direct reports were competent based on their title alone, but they did not believe their supervisors assumed they were competent because of title alone. Instead, respondents described strategically communicating to their supervisors to highlight their competence, leaning on symbols, or working especially hard during the initial trust-building period to build confidence in them. As well, some respondents made a specific point to mention that just because their supervisor had a certain title did not automatically mean they were good at their job. Respondents would assess whether supervisors were pencil-whipped (i.e., promoted too quickly without the necessary experience), took unconventional routes to their position, or had been away from on-the-ground firefighting for too long and had lost touch with the experience of being a firefighter.

Thus, while diversity of experience was valuable, experience as the number of years in fire or in a high-level incident management team was not always an automatic asset for supervisors.

3.3.1.2 Operationally sound decision-making

Perhaps unsurprisingly, across all trust referents it was also important to be perceived as operationally sound. This was often described as being able to make "good decisions" regarding plans and tactics. Regardless of trust referent, competent trustees were those who could generate well thought out plans based on the information available, that were likely to succeed and did not involve unnecessary risks. Respondents felt their direct reports were looking for supervisors who pursued efficient and effective tactics and who provided clear and transparent expectations and intent. Respondents believed direct reports valued supervisors who were flexible. For example, supervisors should be able to think several days ahead and admit when a plan was not working and change the strategy in light of new information. This matches the expectations respondents had for their own supervisors. Respondents wanted supervisors to develop reasonable plans the first time around, thinking ahead into the future and planning for contingencies, but also adapting in response to new information or feedback from subordinates.

Respondents were also more likely to indicate that trust could be task-specific for direct reports: they may trust a direct report to carry out specific tactics or operations rather than broadly trusting them to do any variety of tasks. While they may have felt their supervisors wanted them to be problem-solvers, few respondents said they were looking for "problem-solving" or "problem solvers" in their direct reports or supervisors; "solving problems" primarily was unique to felt trust from supervisors. When discussing their own direct reports,

respondents were more likely to indicate they trusted direct reports who worked diligently and efficiently and who met objectives and achieved desired results.

This desire for subordinates to follow plans and meet objectives but for supervisors to adapt to subordinate feedback and "sell" subordinates on their plan could lead to positive outcomes, where subordinates were included in decision-making and the plan had collective ownership. However, respondents also had experiences where it led to tension when subordinates and supervisors did not agree on how feasible or safe a plan was. In those cases, subordinates felt they were being put in a dangerous position for no reason while supervisors believed their direct reports were not meeting expectations of performance and deference to authority.

3.3.1.3 Leadership

Leadership was also a valued trait across trust referents, but what constituted good leadership and how much it was valued varied. Leadership was most important for felt trust from subordinates. Respondents believed their subordinates wanted them to display leadership skills through confidence. This included acting decisively, and not being "wishy-washy", especially in stressful environments. However, when respondents were evaluating their own supervisors, they valued not only confidence and decisiveness but also composure and professionalism.

Additionally, respondents valued leadership skills in their direct reports. Many respondents highlighted that trustworthy and capable subordinates were those who were good supervisors themselves, displaying confidence (but not arrogance), keeping their direct reports safe, and not micromanaging them. For felt trust from supervisors, there was not agreement on

what leadership skills were valued, with respondents believing supervisors wanted a variety of characteristics, such as confidence, professionalism, calm, or independence.

3.3.1.4 Communication

Across trust referents, communication skills were important for developing trust. Communication skills were integral to maintaining a shared understanding of the fire and regardless of the referent, respondents emphasized that the ability to communicate plans, tactics, and strategies clearly and effectively was an asset. Respondents believed subordinates wanted them to clearly outline expectations on a fire and wanted their supervisors to do the same. Simultaneously, respondents wanted subordinates to communicate with them diligently and believed their supervisors wanted them to do the same. In addition, public speaking skills, the ability to stand in front of a crowd (be it the public, coworkers, or subordinates) and confidently explain a situation or sell people on a plan was an asset regardless of the individual. Finally, respondents indicated that part of being a good communicator was knowing when to listen and they believed all referents should display good listening skills.

3.3.2 Benevolence

Benevolence is another component of the tripartite integrative model of organizational trust. Benevolence is the extent to which a trustee is believed to want to do good *to the trustor*, aside from egocentric profit motive. Benevolence suggests that the trustee has some specific attachment to the trustor (Mayer et al., 1995). Benevolence is caring for people as people rather than resources. While benevolence was not equally important across trust referents, 100% of respondents mentioned benevolence for at least one trust referent (Table 3.3).

Table 3. 3 Summary of characteristics important for benevolence.

Characteristic	Trust in Subordinates (n = 4)	Felt Trust from Subordinates (n = 20)	Trust in Supervisors (n = 17)	Felt Trust from Supervisors (n = 4)
Collaborative and inclusive leadership	+*	++	++	+
Giving decision-making authority	none	++	++	none
Care and concern for firefighters	+++	++	+++	+

*"+" = one-third or fewer of respondents who discussed benevolence described it with the characteristic, "++" = more than one-third and up to two-thirds of respondents who discussed benevolence described it with the characteristic. "+++" = more than two-thirds of respondents who discussed benevolence described it with the characteristic.

Benevolence was an important characteristic respondents looked for in supervisors and believed their direct reports looked for in them. However, fewer respondents described looking for benevolence in their subordinates, or believing their supervisors wanted them to express it. Thus, benevolence is an important characteristic to be trusted as a leader but is less important as a subordinate. For both felt trust from subordinates and trust in supervisors, respondents described looking for collaborative and inclusive leadership, decision-making autonomy, and genuine care and concern for others, especially those lower in the chain of command.

According to respondents, benevolent leaders make a concerted effort to create an inclusive environment where subordinates feel empowered to contribute to decision-making. This includes not only direct reports, but anyone further down the chain of command, whether they have served on the team before or are a single resource not normally present on the team.

As an example, several respondents described trying to make their subordinates feel included in decision-making by treating them as equals or colleagues rather than as subordinates. Similarly, respondents spoke positively of supervisors who treated people equally regardless of their title or rank in the command structure.

In addition to providing an opportunity for people to contribute to the plan, benevolent leaders also granted their direct reports and subordinates decision-making autonomy. Respondents disliked supervisors who micromanaged and reported trying not to micromanage their direct reports as well. Rather, respondents believed supervisors should set up their direct reports with the tools they need to be successful, and then let them figure out the rest. They believed supervisors should strive to support the people on the ground and give them the space to be successful, rather than supervise and command them.

Finally, respondents believed benevolent leaders genuinely cared about the people working under them. Importantly, benevolent leaders did not just care about their own direct reports but showed particular concern for on-the-ground firefighters. One of the main ways respondents behaved as benevolent leaders was to ensure the needs of firefighters were taken care of; ensuring firefighters had hot food, cold water, and any tools or supplies they needed when they needed them. Respondents also discussed the importance of providing positive feedback and expressing genuine empathy and sympathy when team members experienced failure and frustration. Some described this as “momma bear” or “papa bear” leadership and emphasized the importance of showing genuine care about people’s emotional and mental as well as physical well-being.

3.3.3 Integrity

Integrity involves the trustor's perception that the trustee adheres to a set of principles the trustor finds acceptable (Mayer et al., 1995). 96% of respondents mentioned integrity for at least one trust referent. Integrity was an important component of trust when evaluating the trustworthiness of direct reports and supervisors, as well as felt trust from subordinates. However, fewer respondents mentioned integrity when discussing what they believed supervisors were looking for in them. Although fewer respondents discussed expectations of integrity from their supervisors, those who did generally followed the patterns of the other trust referents, discussing the importance of honest communication, personal humility, and ownership of decisions (Table 3.4).

Table 3. 4 Summary of characteristics important for integrity.

Characteristic	Trust in Subordinates (n = 16)	Felt Trust from Subordinates (n = 12)	Trust in Supervisors (n = 17)	Felt Trust from Supervisors (n = 7)
Honest Communication	+++*	+++	++	+++
Personal Humility	++	+	++	+
Owning Decisions	+	++	+++	++

"+" = one-third or fewer of respondents who discussed integrity described it with the characteristic, "++" = more than one-third and up to two-thirds of respondents who discussed integrity described it with the characteristic. "+++" = more than two-thirds of respondents who discussed integrity described it with the characteristic.

3.3.3.1 Honest Communication

Across referents, an important aspect of integrity was honest communication. Respondents valued supervisors and subordinates who were straightforward and honest, and

believed their subordinates and supervisors expected the same of them. This meant respondents expected supervisors to not be disingenuous when discussing the feasibility and risk associated with a proposed plan. Similarly, they believed their direct reports valued transparency, and would distrust them if they hid information or acted “like a used car salesman”. The flip side of this was that respondents expected direct reports to be honest with their opinions about the plans they were proposing. As one respondent described, they wanted their direct reports to “tell [them] if [their] baby is ugly”. As well, respondents described direct reports who talked badly or gossiped about people behind their back, regardless of whether they were talking about the respondent specifically, as less trustworthy. A few respondents described the rare case of a subordinate going rogue or acting independently. When direct reports openly violated plans or went against orders, respondents would deeply distrust the direct report and in some cases remove them from the fire line.

3.3.3.2 Personal Humility

As previously discussed, many respondents believed direct reports wanted them to be confident and decisive, and across trust referents the ability to be a confident and persuasive public speaker was valued. But simultaneously, respondents would harshly judge people they believed were egocentric or lacked humility. Respondents expected direct reports to be humble, admitting their weaknesses and not overselling their skill set. For supervisors, respondents were often suspicious of those they believed were in fire management for the wrong reasons, such as money, glory, or praise. Respondents believed supervisors should instead be servant-leaders, placing the needs of the team and on-the-ground firefighters above their own. Supervisors who were seen as trying to climb the career ladder too quickly, or at the expense of others, were strongly distrusted. While respondents looked for these characteristics in their direct reports

and supervisors, fewer mentioned their supervisors or direct reports expecting them to display humility.

3.3.3.3 Owning Decisions

Respondents believed a key component of displaying their integrity to direct reports was to take ownership of bad decisions and to protect their direct reports from the blame when things went awry. Respondents described this as “having their subordinates’ backs when things go wrong”, “not throwing them under the bus”, “having the buck stop at them”, and “owning the outcome”. Similarly, respondents were looking for these qualities in their own supervisors. They reported looking to supervisors to support them when things went wrong, whether the mistake was committed by the supervisor or someone lower in the chain of command.

Unique to trusting supervisors, particularly incident command and operation section chiefs, respondents highlighted that it was critical that supervisors resist pressure from the line officer or host unit to engage in ineffective, dangerous, or inappropriate tactics. Respondents believed supervisors should shield their subordinates from political pressure, resisting the temptation to order resources to do tasks outside the scope of fire management or engage in activities solely for performance. Respondents evaluated very negatively supervisors who succumbed to public or political pressure and subsequently put people in risky places.

3.3.4 Predictability

Researchers have recommended the integrative model of organizational trust may be incomplete and have suggested predictability may be an important antecedent to trust (Dietz & Den Hartog, 2006). Predictability is based on the consistency and regularity of behavior of the trustee, separate from their competence or integrity. Although predictability was not mentioned

as frequently as ability, benevolence, or integrity, 70% of respondents mentioned it, and predictability came up for all four trust referents as having two key components. The first was based on familiarity between the trustor and trustee, and the second was based on reliability and availability (Table 3.5).

Table 3. 5 Summary of characteristics important for predictability.

Characteristic	Trust in Subordinates (n = 7)	Felt Trust from Subordinates (n = 9)	Trust in Supervisors (n = 7)	Felt Trust from Supervisors (n = 6)
Familiarity	++	++	+	++
Reliability and Availability	+++	++	+++	++

"+" = one-third or fewer of respondents who discussed predictability described it with the characteristic, "++" = more than one-third and up to two-thirds of respondents who discussed predictability described it with the characteristic. "+++" = more than two-thirds of respondents who discussed predictability described it with the characteristic.

3.3.4.1 Familiarity

Respondents indicated that all else equal, it was easier to trust and be trusted by subordinates and supervisors they were familiar with and had worked with before. Familiarity could come from serving on the same team, crossing paths on different teams, working together locally, or knowing each other outside of fire. Respondents highlighted examples of persevering through particularly difficult experiences together contributing to extremely strong mutual trust. Familiarity helped build trust because trustors could better predict the behavior of trustees. As well, it could make communication more efficient, and helped respondents maintain a shared understanding of the fire across members of the IMT. As a result, single resources, people

ordered to fill a specific role who do not normally roster with the team, started at a lower level of trust until they proved themselves. Familiarity could also be built indirectly through shared or similar experiences. Respondents evaluated and were evaluated by people more positively if they had similar stories or experiences on the job, and during the initial size-up period, respondents and their supervisors and subordinates would look for common ground with each other.

3.3.4.2 Reliability and Availability

Respondents indicated that being reliable and available was an important part of trusting and being trustworthy for both supervisors and subordinates. Respondents highlighted that direct reports needed to be reliable and get their work done in a reasonable timeframe, and believed their supervisors held them to the same standard, valuing perseverance through difficult tasks. Simultaneously, respondents valued supervisors who made themselves available, who were present during meetings and in camp and who could be reached if one had questions or needed clarification. In turn, they believed their own direct reports held them to the same standard. Respondents endeavored to be available for their subordinates, emphasizing the importance of not missing meetings or conversations and responding to requests and radio communications in a timely manner.

3.3.5 Gender

While 6 of the 27 respondents were women, fire management is a male-dominated field. According to the National Fire Protection Association, fewer than 5% of career firefighters are women (Evarts & Stein, 2020). The women in this study each had their own experiences with regards to gender, however, some common themes emerged. Some women mentioned their gender could be an asset in specific cases; direct reports may be more willing to take advice

about wellbeing (e.g., make sure you stay hydrated) from a woman because a female supervisor could take on a pseudo-maternal role. Two male respondents spoke very highly of their experiences with female supervisors, highlighting that those supervisors emphasized communication and interpersonal skills more than the male supervisors they had worked under.

However, typically being a woman was a liability for one's credibility and assumed competence. Respondents described that as women, they had to go beyond what their male colleagues had to do to prove they earned their certification. They described experiences where men believed they had not earned their position and instead were moved up the ranks because of their gender. Indeed, two male respondents mentioned that women were sometimes moved into upper management positions even when they did not have sufficient experience.[2] As discussed previously, fire managers can lean on symbols of competence during the initial size-up. Some of these symbols specifically exclude women. Respondents described that the archetypal fire manager is tall, stoic, muscular, and male. By not fitting that physical appearance, women may not receive the same implicit trust and assumed competence as their male counterparts. As well, multiple respondents described experiencing outright misogyny. These experiences included both supervisors and subordinates specifically excluding the respondent because of their gender or telling the respondent they should not be in fire management because of their gender. Sexism in fire management meant women could never be sure if problems were due to miscommunication, a clash of personality, a difference in opinion, or

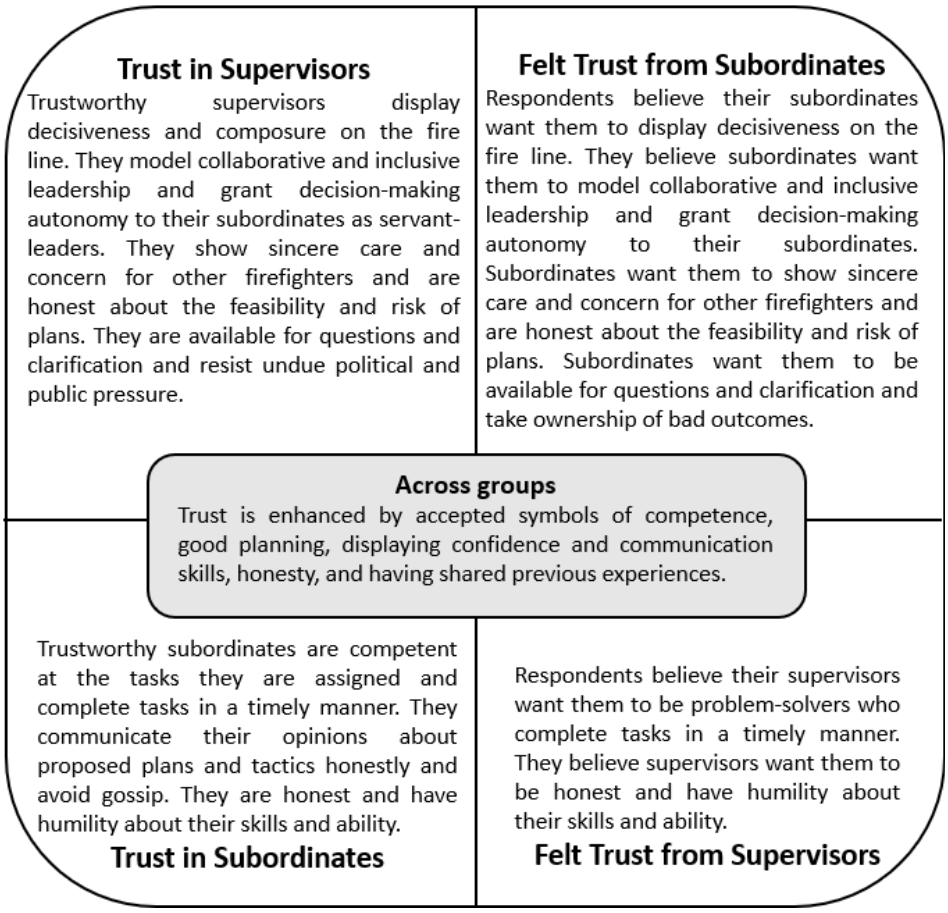
[2] The characteristics of the interviewer will always have an effect on what respondents discuss and how they discuss it. Interviews were conducted by a female graduate student. Although we do not hypothesize how responses would be different if the interviewer had other visible identities, we acknowledge it is very likely this influenced if and how respondents commented on gender and fire management.

misogyny. This uncertainty adds an additional layer of difficulty and self-doubt, and women must be very careful in how they manage conflict as a result.

3.4 Discussion

Two research questions guided this work. Our first research question explored what characteristics operational IMT members look for in trustworthy supervisors and subordinates. Trustworthy supervisors are confident and decisive while modeling inclusive leadership and sincere concern for those lower in the chain of command. Trustworthy subordinates complete tasks in a timely manner and communicate their skills and opinions honestly. Our second research question explored whether respondents believe their supervisors and subordinates are looking for the same trustworthiness characteristics in them. We find evidence that felt trust is largely reflexive with some key differences. While integrity is a key component of trusting supervisors, it is not as salient for feeling trusted by subordinates. Women may feel less trusted by both supervisors and subordinates than their male counterparts, due to both implicit and explicit misogyny. Regardless of the trust referent, trustworthiness is enhanced by identifying shared experiences, utilizing accepted symbols of competence, and displaying strong operational and communication skills (Figure 3.3).

Figure 3. 3 Summary of important characteristics across trust referents.



3.4.1 Theoretical Implications

Previous research on felt trust has often used reflexive wording of existing measures of trust and trustworthiness under the assumption that trust and felt trust are based fundamentally on the same psychological antecedents (Bernstrøm & Svare, 2017; Lester & Brower, 2003). Our results highlight that trust and felt trust are similar, but not identical. At the broadest level, respondents looked for ability, integrity, benevolence, and predictability to determine whether someone was trustworthy and whether they feel trusted. Respondents also seemed to evaluate trust and felt trust consistently across levels of authority. Generally, respondents looked for the same traits in their supervisors that they believed their subordinates looked for in them, and vice versa. However, the relative importance of each characteristic may

differ. For example, we find qualitative evidence that integrity may be more important for trusting subordinates than it is for feeling trusted by supervisors, and gender plays an important role in receiving trust in male-dominated fire management. Whether the relative importance of trustworthiness characteristics is consistent across levels of authority will require additional quantitative analysis. However, the similarities between the structure of trustworthiness and felt trustworthiness highlight that all the complexity inherent to trust applies to felt trust as well, including the need to evaluate trust across multiple trust referents simultaneously (Fulmer & Gelfand, 2012) and over time(Jones & Shah, 2016), and context-specific antecedents (Brandebo et al., 2013).

The relative importance of different components of trustworthiness across level of authority is difficult to evaluate without considering multiple trust referents simultaneously (Fulmer & Gelfand, 2012). Although we do not quantitatively measure trust, our results provide preliminary evidence to suggest the importance of different trustworthiness characteristics depend on the level of authority of the trustee. For example, respondents were more likely to describe the importance of benevolence for felt trust from subordinates and trust in supervisors than trust in subordinates or felt trust from supervisors. This is similar to earlier qualitative work evaluating the importance of different trustworthiness characteristics in Scandinavian military officers: ability, benevolence, and integrity are valued in both supervisors and subordinates, but benevolence more important for supervisors than subordinates (Brandebo et al., 2013). As well, even though respondents may look for the same characteristics across levels of authority, how they manifest and what those characteristics mean may differ. For example, for both supervisors and subordinates, honest communication was a key component of integrity, but

supervisors had the additional obligation to own the outcomes of bad decisions and shield subordinates from fallout.

This study also highlights the different ways that ability, benevolence, and integrity may be conceptualized based on the trust context. The integrative model provides overarching definitions of these concepts, and many researchers have used the instrument developed for the integrative model (Mayer & Davis, 1999) in their studies. However, McEvily and Tortoriello (2011) argue the trust literature is characterized by inconsistent or context-specific measurements of trust, which affects the ability to speak to the effects of trust across domains. Our results highlight one example where it may be less effective to use an existing measure. Although IMTs use the broad criteria described by the integrative model, the exact behaviors and tasks captured in the existing quantitative measure are not the best reflections of the IMT experience. While it is not ideal that trust has been measured many ways, in some cases it may be justified when using more generalizable instruments provides a less reliable and precise measure of trust than one developed for the study context.

While the integrative model seems to accurately describe felt trust in incident management teams, it does not completely describe it. Researchers have argued predictability is a key component of trustworthiness missing from the integrative model (Breuer et al., 2019; Dietz & Den Hartog, 2006). We also find evidence it is similarly missing from evaluations of felt trustworthiness. Future studies of felt trust and felt trustworthiness should be cautious using reflexively-worded existing measures when those measures may be incomplete. When evaluating and measuring trust and felt trust in less-studied contexts, such as in emergency management, it is important to interrogate model applicability (Brandebo et al., 2013; Mishra & Mishra, 2013). In our results, gender likely does not indicate the integrative model is

incomplete, but rather highlights the importance of considering context-specific aspects of trustworthiness when applying broad models of trust. Further, while the goal of our study was not to describe how trust develops over time, respondents provided examples of trusting relationships developing from two strangers sizing one another up to a functional temporary relationship or in some cases a career-long friendship. These examples highlight that trust develops additional dimensions as relationships mature, beginning with cognitive trust based on confidence and with time evolving to affective trust based on shared experience (McAllister, 1995).

3.4.2 The State of Trust in Incident Management Teams

Although we did not measure trust directly, respondents typically expressed high trust in other IMT members. Respondents would frequently have to recall events from years prior to provide anecdotes where they distrusted or were distrusted by a team member. There are multiple potential drivers of the high state of trust in IMTs. One is the tendency towards familiarity and repeated interactions. Another is the role of swift trust and category-driven trustworthiness. We will discuss each of these in turn.

The incident management system may naturally trend toward teams with high trust and cohesion. Respondents described that untrustworthy or underperforming direct reports ordered as single resources are often not invited back to teams, and people generally do not re-roster with teams led by supervisors they distrust. Similarly, familiarity and shared experiences over time cultivates trust between IMT members. Therefore, IMTs may trend toward trust and cohesion over time for returning members. Previous research stresses the importance of technical specialists and operations personnel developing personal relationships by having in-person interactions and serving on the same team repeatedly (Rapp et al., 2020). It is

unsurprising the same is true for trust between members of the operations section. However, this process may be slow as membership on teams is fluid and teams are deployed infrequently, especially outside of the main fire season (Hayes, 2014). Thus, at least during initial size-up, swift trust" may help explain how IMT personnel rapidly develop trust in one another in absence of repeated interactions.

Although the core IMT can be sustained across incidents and over time, many of the personnel who serve on incidents are not tied to a team and are ordered as needed. Thus, there will always be a need to rapidly assess individuals throughout the chain of command. Our results indicate that trust can develop rapidly on the fire line based on word-of-mouth reputation and accepted symbols of competence. This is indicative of the concept of swift trust (Meyerson et al., 1996). Swift trust enables individuals to rapidly build trust in one another based on features of the setting rather than the trustee (Meyerson et al., 1996). Swift trust is not based on affect, but rather categorical characteristics such as role or qualification, augmented by institutionalized and well-defined roles.

While official roles such as incident qualification can help rapidly establish confidence between team members, other categories used to infer trustworthiness warrant greater scrutiny. IMT members are aware of and accept other ways IMT personnel are categorized, such as home location, even while aware these categories may not accurately reflect their skill set. While it may be true IMT members are more skilled in their home region and ecosystem than outside it, it is worth interrogating how valid other commonly used cues are. For example, are IMT members justified in assuming team members from the Midwest or Southern United States are not as capable as their Western peers at managing Western wildfires? Across contexts, research suggests when individuals distrust their team members, they spend more time

monitoring and double-checking distrusted team members(De Jong & Dirks, 2012; McLennan et al., 2006), and thus unwarranted distrust may come at a cost to team performance and efficacy (de Jong et al., 2016).

For less conscious or tangible cues, it is especially worth interrogating whether these are indicative of a good IMT member. Respondents described that the archetypal fire manager is a representation of classic masculinity: tall, stoic, muscular, and male. This archetype excludes men who do not conform to this standard and all women. Yet respondents described qualities they valued in trustworthy team members that are not endemic to stoic masculinity, including communication skills, concern for the physical, emotional, and mental wellbeing of team members, and inclusive leadership and a flattened hierarchy of authority. These are similar to the qualities valued in leaders in fire management (Waldron et al., 2015; Waldron & Schary, 2019) and exemplary incident commanders (Boyatzis et al., 2017). Emergency management requires team members to have both task and teamwork based skills (Hayes, 2014; Hayes et al., 2021); it appears the automatic associations of what makes a competent fire manager have not kept up with the currently valued skills for competent leadership.

In addition, supervisors seem to have additional obligations to prove their trustworthiness compared to subordinates. Respondents were less likely to grant supervisors assumptions of competence based on qualifications alone, and respondents believed supervisors needed to display benevolence in addition to ability and integrity. Trust is the willingness to be vulnerable (Mayer et al., 1995; Rousseau et al., 1998) and in the context of emergency management it is unsurprising supervisors, who make decisions that directly influence the physical safety of their subordinates, are held to a different or higher standard than subordinates. However, the relationship between high-risk contexts and the characteristics

that determine trustworthiness are unclear. These results are in contrast to previous work on supervisors in military contexts where fewer than 20% of respondents described benevolence for developing trust in supervisors (Brandebo et al., 2013). As well, previous work on structural firefighting suggests affective trust is less important than calculative trust for high-reliability tasks (Colquitt et al., 2011). However, these results are in line with the interpersonal and non-technical skills valued in wildland fire management. Even in the context of teams that work in emergency management, there may be systematic differences in the relative importance of different characteristics for trust-building. The desire for supervisors to be in fire management "for the right reasons" and not climb the career ladder may suggest IMT personnel may trust the IMT qualification system to produce competent and qualified on-the-ground firefighters and middle managers, but not effective leaders at the higher levels of incident management. Regardless, this work points to steps IMT members can take to cultivate trust from their subordinates and fellow team members.

3.4.3 Steps to Cultivate Trustworthiness in Incident Management Teams

These results suggest several ways to bolster trust between members of incident management teams. Because many IMT members are both supervisor and subordinate, there are few positions that should not be targeted for professional development opportunities to develop trust-building skills. However, some skills are valuable in both supervisors and subordinates, whereas some are more important for team members acting as supervisors.

In general, team members are better able to build trust if they are more familiar with one another. Intra-team familiarity is also important in its own right for fast and accurate decision-making (Hayes, 2014). Hayes (2014) recommends two approaches for building familiarity in emergency management teams. First, training exercises with mixed-familiarity

personnel help team members build familiarity and capitalize on different perspectives before actual emergencies arise. Second, because ad hoc teams are inevitable, team members should use brief resumes and/or short question and answer sessions to evaluate category-based trustworthiness and establish swift trust. The latter recommendation builds on the already existing sizing-up process in which team members engage. While it is likely that team leaders question new or unfamiliar personnel, it is important supervisors also make this information available for subordinates to develop trust in them.

Although swift trust and category-based trust enable teams to function effectively, it is important to note that more trust is not always an unalloyed good. Category-based evaluations of trust are derived heuristically based on the shorthand decision rule that if an individual belongs to a certain category, they are a certain level of trustworthiness. However, trust based too strongly on group identification can have negative ramifications, including insufficient critical evaluation of group members and organizational inertia and rigidness (McEvily et al., 2003). Trust as a heuristic enables team members to rapidly evaluate whether information is valuable. But excessively dense, bonded networks categorized by high intra-team trust may limit their access to new information as team members rely on each other rather than technical specialists (Rapp et al., 2020), other sections of the IMT (McLennan et al., 2006), or inter-agency partners (Nowell et al., 2017).

To move beyond category-based, swift trust and foster affective and cognitive trust, it is important to develop trustworthiness. There are two steps to developing trustworthiness. Team members must embody trustworthy characteristics and they must have these characteristics recognized by trustors. For example, a key component of ability is displaying adaptability and long-term thinking with regards to plans and tactics. For higher-level operations personnel and

incident commanders, many decision support tools exist to try to foster adaptability and help fire managers think several days out when planning strategies and tactics (e.g., Calkin, Thompson, Finney, & Hyde, 2011; Finney et al., 2011). It is worth exploring professional development opportunities that can foster these skills in IMT members. Professional development opportunities are often lacking for important skills like risk management (Canton-Thompson et al., 2008; Thompson, Rodríguez y Silva, et al., 2017) and aptitude using decision support tools (Noble & Paveglio, 2020; Rapp et al., 2020). Offering these opportunities could not only improve the technical competence of IMT members but also bolster trust between team members. However, technical competence may not be recognized without the ability to articulate and display it to team members. Thus, communication skills may be the bedrock for developing trustworthiness in IMTs.

Communication skills have a direct effect on assessments of trustworthiness by enhancing evaluations of ability. In addition, rapid communication of shared experience and expertise can further calibrate evaluations of competence during initial size-up. Communication is also related to other aspects of trustworthiness. Benevolent leaders use inclusive communication, and honest communication is a key aspect of integrity. Training in communication skills is generally limited and focused on technical skills such as how to speak over the radio and not on implicit communication skills (Black et al., n.d.). This is true even though communication is recognized as critical for team functioning (Bearman et al., 2015) and is a highly valued skill (Hayes et al., 2021; Hayes & Omodei, 2011). Greater opportunities to develop communication skills should therefore be a high priority to improve team functioning and efficacy at all levels of the IMT.

Finally, certain characteristics are valuable for supervisors to inspire trust in their subordinates. Because many IMT members act as both supervisor and subordinate and supervisors may start with less trust than subordinates, these characteristics should be widely cultivated. Although supervisors should not fully defer to their subordinates and relinquish their authority, when time permits supervisors should model collaborative and inclusive leadership and solicit feedback and information from their subordinates. Collaborative and inclusive leadership may be particularly important for subordinate psychological safety. Novice and intermediate IMT members may feel social pressure to not speak up about plans and tactics (Lewis et al., 2011). This is problematic, as firefighters lower in the chain of command may have a more accurate assessment of on-the-ground conditions. While novice firefighters may be less able to discern and interpret environmental cues. Being included in decision-making and feeling empowered to ask questions and participate may be an important mechanism for developing expertise.

As well, where prudent, supervisors should grant their subordinates autonomy to make decisions and solve problems. Notably, this is in line with previous literature that outlines the characteristics of high reliability organizations (HROs). HROs are organizations that are able to work in contexts of extreme risk with no errors (Black & McBride, 2013). Supervisors play a key role for high reliability performance by fostering cross-level communication to help the team maintain and update a shared understanding of the fire event (Jahn & Black, 2017). Additionally, one of the phenomena that characterize HROs is authority migration or deference to expertise, where HRO members look to the person with the most expertise in an area to solve a problem rather than the person with the highest rank (Bigley & Roberts, 2001; Black & McBride, 2013).

Inclusive leadership and decision-making autonomy may positively contribute to the capacity for IMTs to function as HROs.

3.5 Conclusion

Incident management teams work in a uniquely risky environment, where individuals both trust and are trusted by their supervisor and subordinates. In line with previous research, we find that IMT members look to the ability, integrity, and predictability of their team members and the benevolence of their supervisors when evaluating trustworthiness. In general, IMT members hold themselves and their team members to the same standards of trustworthiness. In other words, the characteristics they look for in a trustworthy supervisor are those they believe their subordinates also look for in them, and vice versa. While this work suggests the importance of different trust characteristics varies across trust referent (e.g., displaying integrity seems to be less important for feeling trusted by supervisors than developing trust in subordinates), future research should quantitatively examine both trust and felt trust across multiple trust referents. As well, while trust and felt trust are similar, they are not identical, and more work should be done to determine when reflexively-worded versions of trust measures are appropriate for measuring felt trust. In general, trust is high, but supervisors may have more to prove than subordinates before they are trusted, and women have unique challenges to giving and receiving trust in the male-dominated fire management environment. Given the importance of trust in team performance across domains, incident management team members may want to cultivate trustworthy characteristics and interrogate dominant social cues that may not be valid signals of ability. Fostering communication skills seems critical for promoting trust, as they are a valued skill, and they enable team members to communicate their

integrity and benevolence more effectively. When able, supervisors should also emphasize inclusive leadership and seek the input of their subordinates.

Chapter 4. An analysis of the role of trust in and felt trust from supervisors on incident management team learning and performance

4.1 Introduction

Trust is the willingness to be vulnerable to the actions of the trustee because of positive expectations that the trustee will perform a particular action (de Jong et al., 2017; Mayer et al., 1995; Rousseau et al., 1998). Commonly, trust is conceptualized with two dimensions, a cognitive dimension formed earlier in the relationship based on a calculative assessment of trustworthiness, and an affective dimension formed later based on positive evaluations of the trustee (Jones & Shah, 2016; McAllister, 1995). Trust and trustworthiness are important for effective team performance (Colquitt et al., 2007). Trust enables better team performance by improving how well team members share information with each other (Chowdhury, 2005; Levin & Cross, 2004), reducing the energy team members need to put into monitoring one another (De Jong & Elfring, 2010), and fostering risk-taking and innovation (Neves & Eisenberger, 2014). Trust can function as a heuristic that allows team members to rapidly assess the accuracy and validity of information based on the trustworthiness of the information source (McEvily et al., 2003). Trust between team members is particularly important for teams with authority and skill differentiation and interdependent tasks (de Jong et al., 2016).

Researchers have increasingly become interested in the boundary conditions and contingencies of trust (de Jong et al., 2017). In particular, it is fruitful to expand the contexts or domains in which trust in team members and supervisors is examined (Curnin et al., 2015). Existing theories and frameworks for trust in typical organizational teams may not be applicable

to teams that work with serious risks to personal safety (e.g., military teams) (Brandebo et al., 2013). Authors have called for greater analysis of trust among team members who work in environments involving high degrees of uncertainty, vulnerability, or stress (Mishra & Mishra, 2013).

One example of organizational teams that work in uncertain and potentially dangerous contexts is High Reliability Organizations (HROs). HROs are categorized by their work in high-risk contexts, where failure is likely to be catastrophic and therefore trial-and-error learning is limited (Medeiros, 2009). HROs manage a variety of hazards and technologies and examples include air traffic controllers (Medeiros, 2009), nuclear aircraft carriers (Roberts, 1990), and incident command systems (ICS) (Bigley & Roberts, 2001). The ICS is the mandatory organizational structure for all emergency management in the United States, providing a consistent chain of command, roles, and responsibilities across emergency management contexts (Jensen & Thompson, 2016). Consequently, the ICS plays a pivotal role in shaping how wildland fires are managed. In the United States, all fires that are not contained within 48 hours (called initial attack) are managed by incident management teams (IMTs) which use hierarchically arranged, pre-determined roles and responsibilities mandated by the ICS (National Wildfire Coordinating Group, 2013). IMTs work in environments categorized by high risk and uncertainty, as conditions evolve over the course of a single fire event (Thompson, Rodríguez y Silva, et al., 2017). Scholars have qualitatively discussed trust in IMTs but empirical analysis of the psychological structure of trust and the function of trust in teams is limited (Bigley & Roberts, 2001; McLennan et al., 2006; Rapp et al., 2020). Due to the hierarchical nature of IMTs and the inherent danger of working in fire management, supervisors in IMTs must manage risk on behalf of their subordinates, and subordinates in turn must trust their supervisor is not

placing them in serious or unreasonable danger. Consequently, in this study we focus on the trust relationships between IMT members and their supervisors.

4.1.1 Background

According to the integrative model of organizational trust, intention to trust is driven by characteristics of the trustor and the trustee (Mayer et al., 1995). Among trustors (the entity exhibiting trust), propensity to trust is important for the initial relationship and shapes subsequent trust development (Ferguson & Peterson, 2015; van der Werff & Buckley, 2017). Among trustees (the entity being trusted), the integrative model posits that trustworthiness is a function of the ability (competence in a specific domain), benevolence and integrity(desire to do good to the trustor), and integrity (adherence to acceptable principles) of the trustee (Colquitt et al., 2007). However, several others have pointed out that trustee predictability is an important component of trustworthiness missing from the integrative model (Breuer et al., 2019; Dietz & Den Hartog, 2006). The factors that contribute to trustworthiness and their relative importance may also differ for teams like IMTs that work in high risk, dangerous circumstances. Adams and Webb (2003) explore trustworthiness in the context of military teams and organize trustworthiness into person-based and category-based factors. Person-based factors include predictability, ability, benevolence, and integrity but also include interactive factors like communication, values, and shared goals. Category-based factors are the social categories one belongs to (e.g., attained rank, medals and honors).

To fully understand the trust relationship between an IMT member and their supervisor, it is necessary to evaluate both trust and felt trust (Brower et al., 2000). Less well-examined than trust, felt trust includes the process and outcomes of feeling trusted by a person, team, or organization. Commonly, trust is examined through the lens of social exchange. Social exchange

theory argues that parties exchange resources through rules of engagement. Depending on the resources and rules used to exchange them, different relationships emerge. Some social exchanges can lead to unspecific, diffuse obligations that engender feelings of gratitude and trust (Blau, 1964; Cropanzano & Mitchell, 2005). For example, sharing information and services (resources) through a social norm of reciprocity (exchange rule) can lead to diffuse obligations and greater commitment to the relationship (Cropanzano & Mitchell, 2005). In comparison, there is no theoretical agreement on felt trust, and authors have taken a variety of perspectives to examine it. Early work on subordinate felt trust from leaders suggested felt trust derived from leader risk-taking: leaders trust subordinates and engage in behavior that puts the supervisor at risk, such as disclosing sensitive or personal information or relying on the subordinate to complete important tasks. Subordinates recognize this risk-taking behavior and subsequently feel trusted (Brower et al., 2000). Consequently, felt trust can be inferred by individuals, and therefore measured, based on felt reliance and felt disclosure (Lau et al., 2007). However, studies to date suggest felt reliance, but not felt disclosure, contribute to felt trust from supervisors (Lau et al., 2014; Zheng et al., 2019). Additionally, recent work challenges this external pathway for establishing felt trust. Campagna et al. (2020) observe that rather than felt trust being an external process of observing someone else's behavior and surmising if they trust you, felt trust is decided through an internal process of assumed reciprocity. Accordingly, individuals evaluate how much they trust someone and then use lay theories of reciprocity to approximate felt trust in turn (Campagna et al., 2020). Other researchers have drawn on the integrative model of organizational trust and examined felt trust from the perspective of felt trustworthiness: individuals feel trusted if they believe others view them as someone with ability, benevolence, and integrity (Bernstrøm & Svare, 2017; Lester & Brower, 2003).

Little is known about the structure and function of felt trust and felt trustworthiness among teams like IMTs that work in high risk or emergency management. To date, organizational research on teams that do not work in a hazardous context have largely measured felt trust through reflexively worded versions of existing trust scales (e.g., Bernstrøm & Svare, 2017; Hanna et al., 2019; Lau et al., 2014; Zheng et al., 2019). Earlier qualitative work on IMT members suggests supervisor trustworthiness is a function of the supervisor's ability, benevolence, integrity, and predictability. However, when evaluating felt trust from supervisors, IMT members primarily discussed ability and to a lesser extent integrity and predictability. Fewer respondents discussed benevolence as an important aspect of felt trustworthiness. This study builds off the previous work on felt trust and IMTs by empirically modeling trust and felt trust through path analysis. Establishing clarity in construct and measurement is important for laying the groundwork for future work on felt trust across domains. As a result, we hypothesize the following:

> **Hypothesis 1:** Supervisor ability, benevolence, integrity, and predictability positively contribute to trust in supervisors.
>
> **Hypothesis 2:** Felt ability, felt benevolence, felt integrity, and felt predictability positively contribute to felt trust from supervisors.

As different but related concepts, it is unclear if trust and felt trust are additive, multiplicative, or substitutable. Felt trust from supervisors has a positive effect on team performance by increasing individual intrinsic motivation (Bernstrøm & Svare, 2017), feelings of empowerment (Gill et al., 2019), and self-efficacy and organizational citizenship behavior (Lau et al., 2014; Zheng et al., 2019). Felt trust can also have a deleterious effect by increasing perceived

workload and reputation maintenance concerns (Baer et al., 2015). Trust also bestows benefits onto the trustee in the form of greater resources (Dirks & Skarlicki, 2009). However, few studies have measured trust and felt trust simultaneously. One notable exception by Lester and Brower (2003) found that felt trustworthiness from supervisors, not supervisor trustworthiness, was positively and uniquely related to organizational citizenship behavior and job performance. To date, no work has examined the effects of both trust in supervisors and felt trust from supervisors on team performance in IMTs.

Supervisors have an important impact on overall team performance in IMTs. One of the ways supervisors influence IMT performance is through fostering team learning behavior through communication and information sharing. Supervisors can model inclusive communication, shaping how team members talk to one another (Jahn & Black, 2017). Modeling inclusive communication is important for safety and situational awareness; on-the-ground firefighters with less authority can have the most accurate assessment of fire behavior and conditions, but may feel stigmatized for speaking up (Lewis et al., 2011). Inclusive communication is also important for maintaining a shared understanding of the fire between team members (Jahn & Black, 2017). Disconnects or disparities between team members' understanding of the fire can lead to breakdowns that cause IMTs to stop functioning effectively (Bearman et al., 2015). In non-emergency workplace settings, trust in supervisors (Lee et al., 2010) and felt trust from supervisors (Nerstad et al., 2018) positively influences how much knowledge team members share with one another. Given the importance of the supervisor for communication dynamics, trust in and felt trust from supervisors should influence how team members engage in team-learning behaviors by sharing information and communicating with each other, which in turn influences overall team performance. As a result, we hypothesize the

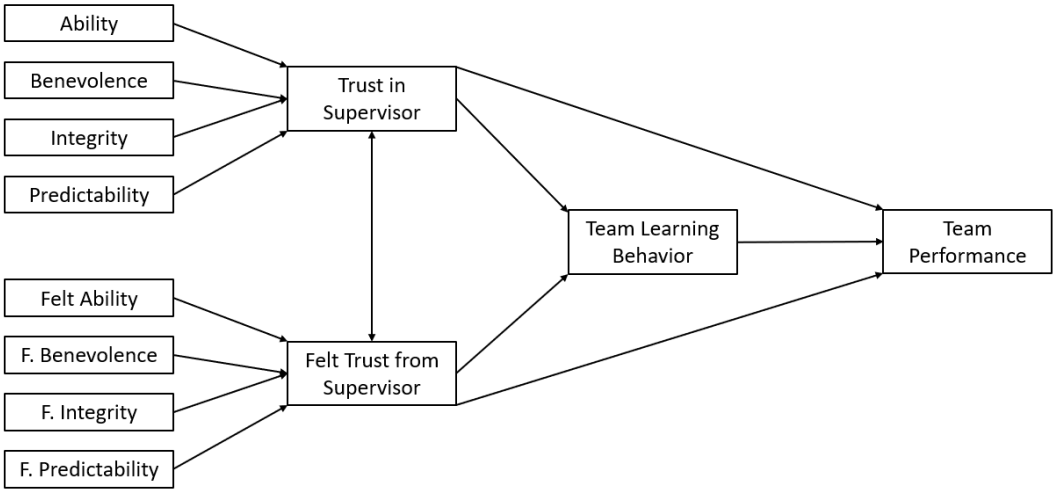
following (see Figure 4.1 for the full theoretical model with the proposed measures of trust and felt trust, and the hypothesized relationships):

Hypothesis 3: Trust in supervisors is positively related to team learning behavior.

Hypothesis 4: Felt trust from supervisors is positively related to team learning behavior.

Hypothesis 5: Team learning behavior is positively related to team performance.

Figure 4. 1 The full theoretical model



4.2 Methods

4.2.1 Subjects

The data presented here come from a web-based survey sent to federal and state fire managers (defined below) working for the United States Department of the Interior (including the US Fish and Wildlife Service, Bureau of Land Management, and National Park Service), the California Department of Forestry and Fire (CALFIRE), the Colorado Division of Fire Prevention and Control (CDFPC), Idaho Department of Lands (IDL), Oregon Department of Forestry (ODF) and Washington Department of Natural Resources (WDNR). States were selected for inclusion

due to their significant fire behavior and large state-level fire-suppression capacity. We received contact information for potential participants through federal Freedom of Information Act (FOIA) requests and state-level public records requests.[3] For this survey, we specifically targeted mid- to upper-level operational fire personnel and incident commanders, including Type 1 -4 incident commanders, operation section chiefs, and division supervisors (see Appendix C for full survey).

Through public records requests, we received 2,325 valid emails. Surveys were conducted over Qualtrics, a web-based survey platform. 537, or 23% responded. After removing respondents who did not make it to the relevant portion of the survey, the final sample included 367 respondents, for an adjusted response rate of 16%.

4.2.2 Measures

4.2.2.1 Descriptive measures

The survey included questions about how long participants had worked in their most frequent fire management role, and in fire suppression and management overall. It also asked them in which geographic region they were stationed and for which agency they worked. In this study we focused on the trust dynamics between the respondent and their supervisor on their most recent large fire. To aid in recall, we asked participants to discuss the last fire they served on. We measured several variables regarding fire managers' most recent assignment, including approximately how long ago the fire was, what position respondents served as, and whether

[3] The research team was unable to acquire contact information for employees working for the US Forest Service through FOIA requests, thus, US Forest Service employees were not included in this study.

respondents were a regular, recurring member of the team or a single resource ordered for that specific fire.

4.2.2.2 Trust, felt trust, team learning, and team performance measures

After respondents recalled their most recent experience on a fire that lasted more than 48 hours, they answered questions about their perceived trustworthiness of and trust in their supervisor as well as their felt trustworthiness and felt trust from their supervisor for the aforementioned fire event. Respondents were randomly assigned to answer trust or felt trust questions first. See Table 4.1 for all trust, felt trust, team learning, and team performance measures.

Ability and felt ability were each measured through 3 items based on the measures for the integrative model of organizational trust (Mayer & Davis, 1999) and the results in Chapter 3. For example, while the integrative model uses broadly focused items such as “top management is very capable of performing its job”, we used specific skills and competencies highlighted in Chapter 3, in language closer to how fire managers described them, e.g., “my supervisor had well thought-out plans for how to achieve their goals”. Integrity, felt integrity, benevolence, and felt benevolence were similarly based on both the integrative model and the results of Chapter 3. Predictability and felt predictability were based exclusively on the results of Chapter 3. Across ability and felt ability, items measured the same skills and competencies but differed on the referent (e.g., “My supervisor had well thought-out plans for how to achieve their goals” and “my supervisor thought I had well thought-out plans for how to achieve my goals”). The same is true for benevolence and felt benevolence, integrity and felt integrity, and predictability and felt predictability.

Trust and felt trust items were adapted from an existing measure of felt trust (Salamon & Robinson, 2008). Trust and felt trust were each measured through 3 items. This measure has been used multiple times in recent studies of felt trust from supervisors (Hanna et al., 2019; Nerstad et al., 2018). Team learning was measured through 6 items adapted from the original 7-item scale designed to measure team behavior in work teams (Edmondson, 1999). Team performance was measured through 4 items based on the results in Chapter 3. All trust, team learning, and team performance items were measured on a 7-point scale from strongly disagree to strongly agree.

Table 4. 1 Measures of trust, felt trust, team learning, and team performance

Construct	Source	Item
Supervisor Ability	Chapter 3, Mayer & Davis, 1999	My supervisor had well thought-out plans for how to achieve their goals.
		My supervisor produced results.
		My supervisor had excellent communication skills.
Supervisor Integrity	Chapter 3, Mayer & Davis, 1999	My supervisor was honest when discussing plans and strategies.
		I believe my supervisor was in fire management for the right reasons.
		My supervisor owned bad outcomes instead of passing the buck.
Supervisor Benevolence	Chapter 3, Mayer & Davis, 1999	My supervisor modeled inclusive leadership for the rest of the team.
		My supervisor gave everyone autonomy to make decisions.
		My supervisor genuinely cared about the other members of the team.

Table 4.1 cont'd

Construct	Source	Item
Supervisor Predictability	Chapter 3	I was familiar with my supervisor before this fire.
		My supervisor had a similar "slide deck" of experiences as me.
		I shared common ground with my supervisor.
Trust in Supervisor	Salamon & Robinson, 2008	My supervisor showed through their behaviors that they were trustworthy.
		I had confidence in my supervisor.
		My supervisor was trustworthy.
Felt Benevolence	Chapter 3, Mayer & Davis, 1999	My supervisor thought I modeled inclusive leadership for the rest of the team.
		My supervisor thought I have my subordinates autonomy to make decisions.
		My supervisor thought I genuinely cared about the other members of the team.
Felt Predictability	Chapter 3	My supervisor was familiar with me before this fire.
		My supervisor thought I had a similar "slide deck" of experiences as them.
		My supervisor thought I shared common ground with them.
Felt Trust from Supervisor	Salamon & Robinson, 2008	My supervisor showed through their behaviors that they trusted me.
		My supervisor clearly communicated they had confidence in me.
		My supervisor believed I was trustworthy.

Table 4.1 cont'd

Construct	Source	Item
Team Learning Behavior	Edmondson, 1999	The team relied on outdated information or ideas. (reverse-coded)
		The team regularly took time to figure out ways to improve its performance.
		Team members asked for help from others in the team when something came up that they didn't know how to handle.
		The team actively reviewed its own progress and performance.
		The team did its work without stopping to consider all the information team members have. (reverse-coded)
		The team ignored feedback from each other. (reverse-coded)
Team Performance	Chapter 3	I believe we managed the fire successfully.
		The team functioned effectively and efficiently.
		At the end of the day, I believe we did a good job.
		We successfully achieved our team-level goals and objectives.

4.2.3 Path analysis

Due to the generally high level of trust and trustworthiness in IMTs, most model variables were not normally distributed. For the path analysis, all variables were transformed into three-level ordinal variables. The items were averaged for each variable and then cutoffs for each were drawn at the 33rd and 66th percentile and recoded on a scale of -1 to 1. See Table 4.2 for cutoff levels and observations per level for each variable. We used the *lavaan* 0.6-9 package in R version 4.1.0 to test the model. We used diagonally weighted least squares (DWLS) to

estimate the parameters rather than Maximum Likelihood (ML) which assumes data is continuous. DWLS is appropriate for ordinal endogenous variables.

Table 4. 2 Ordinal transformations for path analysis

Variable Name	Lower Third (n)	Middle Third (n)	Upper Third (n)
Ability	-3 to 1.66	1.67 to 2.0	2.01 to 3
	156	88	94
Benevolence	-3 to 1.67	1.68 to 2.33	2.34 to 3
	136	107	95
Integrity	-3 to 1.67	1.68 to 2.33	2.34 to 3
	126	116	95
Predictability	-3 to 0.67	0.68 to 2.0	2.01 to 3
	118	123	98
Supervisor Trust	-3 to 1.99	2.0 to 2.339	2.34 to 3
	94	132	111
Felt Ability	-3 to 1.67	1.68 to 2.0	2.01 to 3
	131	108	100
Felt Benevolence	-3 to 1.99	2.0 to 2.33	2.34 to 3
	106	103	129
Felt Integrity	-3 to 1.99	2.0 to 2.339	2.34 to 3
	97	144	100
Felt Predictability	-3 to 0.667	0.67 to 2.0	2.01 to 3
	120	127	90
Felt Trust	-3 to 1.99	2.0 to 2.339	2.34 to 3
	93	138	106
Team Learning	-3 to 0.5	0.51 to 1.67	1.68 to 3
	109	121	94
Team Performance	-3 to 1.5	1.51 to 2	2.01 to 3
	109	113	97

4.3 Results

4.3.1 Respondent Characteristics

On average, respondents had considerable experience in fire management. The mean respondent had been in fire management for 24 years and in their current position for 8 years. Respondents held a variety of qualifications, but a plurality of respondents (34%) were division supervisors most frequently. This is intuitive as division supervisors are more numerous than the other positions requested in the FOIAs. "Other" was the second most common category and included a variety of positions from lower-level operational positions (e.g., strike team leader) to titles from other sections (e.g., planning positions like technical specialists or safety officers). Most respondents were either from state departments (37%) or the Bureau of Land Management (34%). Most respondents (74%) discussed a fire that was 12 or fewer months ago. 73% of respondents were ordered as a single resource, which is to say they were not serving on a team with whom they were rostered. Respondent characteristics are summarized in Figure 4.2 – 4.4.

Figure 4. 2 Incident role respondents served as most frequently (n = 241).

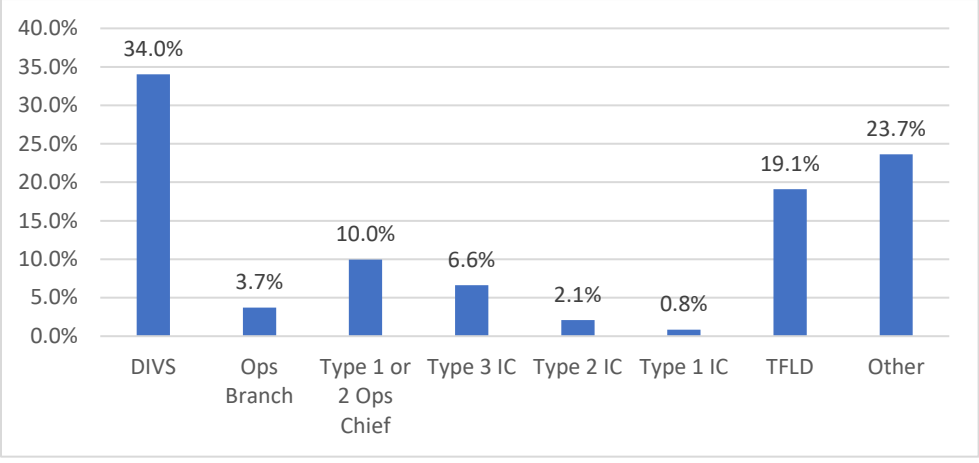


Figure 4. 3 Home agency of respondents (n = 232).

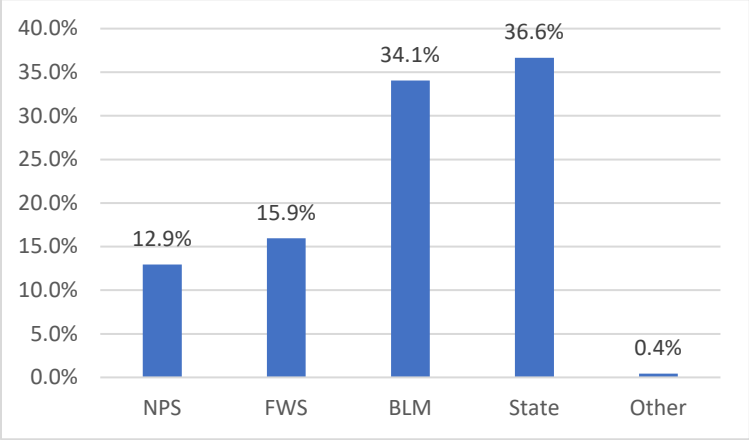
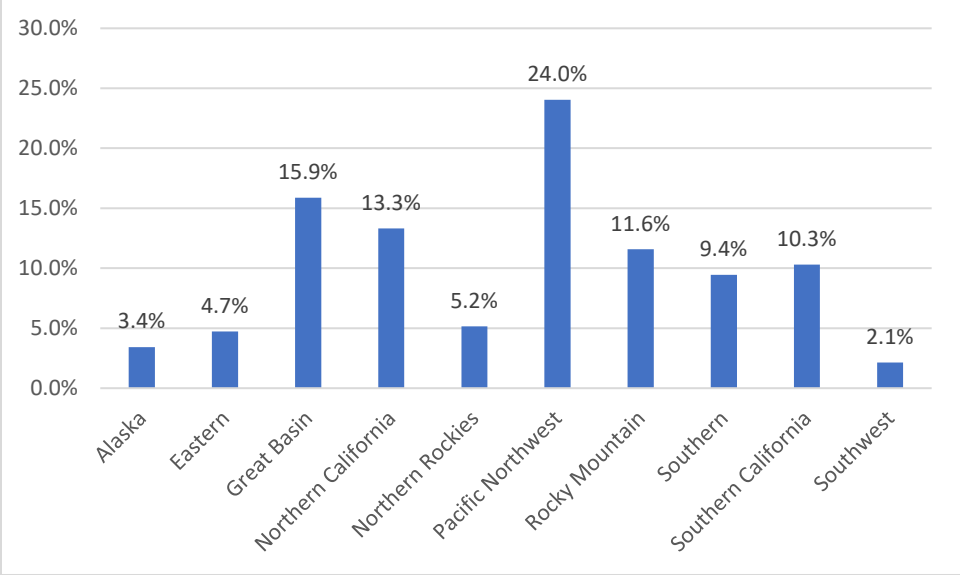


Figure 4. 4 Home region of respondents (n = 233).



4.3.2 The state of trust and felt trust in supervisors and team learning and performance

In general, trust, felt trust, and their antecedents (except predictability) are high. Respondents scored above 1.5 on a scale from -3 to 3 (indicating somewhere between somewhat agree and agree) for all trust variables except predictability, which was still above 1.0 for both predictability and felt predictability (Table 4.3). Predictability and felt predictability are less high, likely driven by the number of participants who were ordered as single resources and were not familiar with their supervisor ahead of time. A series of paired samples t-tests indicates that for each variable, the felt version is higher (e.g., felt trust is higher than trust, felt ability is higher than ability) (Table 4.4). In addition, respondents ordered as a single resource trusted their supervisors less on average and felt less trusted than respondents who were not ordered as a single resource (Trust: $t = -2.31$, p = 0.02. Felt trust: $t = 2.23$, p = .02). There were no significant differences in trust and felt trust based on the position (i.e., task force leader, division supervisor, etc.) participants served on the fire (Trust: $F = 1.58$, p = .17. Felt trust: $F = 1.30$, p = .26).

Table 4. 3 Summary statistics for trust, felt trust, and trustworthiness and felt trustworthiness antecedents

	n	Mean (range -3 to 3)	Std. Deviation
Supervisor ability	338	1.64	1.13
Supervisor integrity	337	1.81	1.13
Supervisor benevolence	338	1.74	1.20
Supervisor predictability	339	1.27	1.34

Table 4 .3 cont'd

	n	Mean (range -3 to 3)	Std. Deviation
Supervisor trust	337	1.88	1.21
Felt ability	339	1.85	0.88
Felt integrity	341	1.96	0.94
Felt benevolence	338	1.85	0.96
Felt predictability	337	1.26	1.32
Felt trust	337	1.94	1.08
Team learning	324	1.03	1.04
Team performance	319	1.66	1.06

Table 4. 4 Paired sample t-tests comparing trust and felt trust variables

Paired difference	Difference of Mean	Std. Error Mean	t-stat	df	Sig (2-tailed)
Trust – Felt Trust	-0.09	0.044	-2.147	330	0.033
Ability – Felt Ability	-0.22	0.048	-4.659	332	0.000
Integrity – Felt Integrity	-0.15	0.049	-3.124	333	0.002
Benevolence – Felt Benevolence	-0.13	0.051	-2.472	332	0.014
Predictability – Felt Predictability	-0.01	0.038	-0.157	332	0.876

4.3.3 Path analysis

Analyses were conducted using the lavaan package in R with the diagonally weighted least squares estimator. All variables were modeled as observed three-level ordinal variables. The model fit moderately well to the data, χ^2 = 166.20, *p<.001*; CFI = 0.76; TLI = .094; SRMR = .04; RMSEA = .07, *p = .02*. Path coefficients are summarized in Table 4.5.

Table 4. 5 Path coefficients

Y	**X**	**β**	**SE.**	**z-value**	**p-value**
Trust	Ability	0.429	0.157	2.73	0.006
	Benevolence	0.952	0.138	6.88	<.001
	Integrity	0.849	0.146	5.81	<.001
	Predictability	0.877	0.18	4.86	<.001
Felt Trust	F. Ability	0.533	0.121	4.39	<.001
	F. Benevolence	0.181	0.114	1.60	0.111
	F. Integrity	0.304	0.127	2.40	0.016
	F. Predictability	0.656	0.164	4.01	<.001
Team Learning Behavior	Trust	0.215	0.059	3.65	<.001
	Felt Trust	-0.07	0.077	-0.912	0.362
Team Performance	Team Learning Behavior	0.57	0.056	10.23	<.001
	Trust	0.04	0.057	0.705	0.481
	Felt Trust	0.061	0.067	0.907	0.364
Covariances		**Estimate**	**SE**	**z-value**	**p-value**
Trust	Felt Trust	0.311	0.082	3.773	<.001

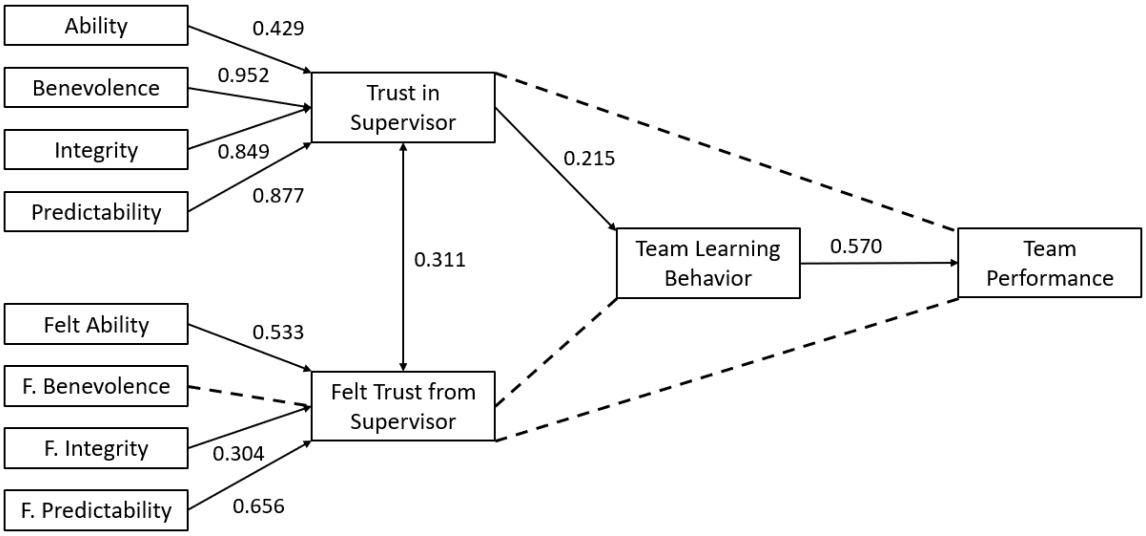
Supporting Hypothesis 1, ability (β = 0.429, *p = 0.006*), benevolence (β = 0.952, *p < .001*), integrity (β = 0.849, *p < .001*), and predictability (β = 0.877, *p < .001*) were positively related to trust in supervisors. We find partial support for Hypothesis 2 as felt ability (β = 0.533, *p < .001*),

integrity (β = 0.304, *p = .016*), and predictability (β = 0.656 *p < .001*) were positively related to felt trust from supervisors. However, felt benevolence was not significantly related to felt trust (*p = .111*). This aligns with the results from Chapter 3, in which respondents valued all four trustworthiness characteristics in their supervisors but were less likely to mention felt benevolence as an important component of felt trust.

Trust in supervisors (β = 0.215, *p < 0.001*) was positively related to team-level information sharing, supporting Hypothesis 3. Felt trust from supervisors (*p = .362*) was not significantly related to team-level information sharing, disconfirming Hypothesis 4.

Team-level information sharing (β = 0.570, *p < 0.001*) was positively related to team performance, supporting Hypothesis 5. Trust in supervisors (*p = .481*) and felt trust from supervisors (*p = .364*) were not significantly related to team performance. Trust in supervisors (β = 0.123, *p < 0.001*) had a positive indirect effect on team performance, completely mediated by team-level information sharing. Felt trust did not have a significant indirect effect on team performance through team-level information sharing.

Figure 4. 5 Final model with coefficients for significant paths (p < .05)



4.4 Discussion

4.4.1 Theoretical Implications

Our results are in line with the literature on the integrative model of organizational trust: supervisor ability, benevolence, integrity, and predictability are all important for developing trust in supervisors (Mayer et al., 1995), which in turn positively influences team performance (Colquitt et al., 2007). We additionally find predictability as a driver of trust in supervisors. The factors that contribute to felt trustworthiness from supervisors are similar but not identical to the factors that contribute to supervisor trustworthiness. In general, respondents rated their felt benevolence highly, indicating they believed their supervisors thought they were benevolent. However, felt benevolence was not significantly related to felt trust from supervisors. There are two potential explanations for why this may be. These potential explanations are not mutually exclusive. First, benevolence may not be an important

characteristic of subordinate trustworthiness. Earlier qualitative work suggests benevolence is less important for trusting subordinates or feeling trusted by supervisors than trusting supervisors or being trusted by subordinates in fire management. While benevolence is important for trusting subordinates in routine team settings (Knoll & Gill, 2011), it may be less important than competence and integrity for trusting subordinates in emergency or high-risk settings (Brandebo et al., 2013). Second, benevolence may not be an important characteristic for felt trust, regardless of level of authority. Trust and felt trust are separate but related constructs (Campagna et al., 2020). Although researchers have often used reflexively-coded items to measure felt trust and felt trustworthiness, it is not uncommon for these measures to behave in slightly different ways. While trustworthiness is multi-dimensional and should be measured as such (Colquitt et al., 2007; Dietz & Den Hartog, 2006), several studies of felt trustworthiness found felt trustworthiness and felt trust were best expressed as a single factor (Bernstrøm & Svare, 2017; Lester & Brower, 2003).

The actual level of trust a supervisor has for their subordinate and the felt trust from the supervisor may also differ in important ways. Being trusted has tangible benefits for the trustee. Receiving trust is important for overall performance because trusted individuals are monitored less (Bernstrøm & Svare, 2017; De Jong & Dirks, 2012) and receive more resources (Dirks & Skarlicki, 2009). On the other hand, *feeling* trusted can have mixed effects for the trusted individuals. Felt trust can positively influence self-efficacy and self-esteem (Lau et al., 2014; Zheng et al., 2019), but feeling trusted can also exacerbate perceived workload and concerns about maintaining one's reputation. An importance distinction is therefore when it is important to *be* trusted and when it is important to *feel* trusted. (Brower et al., 2009). Where outcomes are contingent on the mutual exchange of resources, such as knowledge sharing, mutual trust

and *being* trusted may be more important. In comparison, where outcomes are contingent on trustee perception and attitudes, *feeling* trusted may be more important. The distinction between being and feeling trusted warrants further analysis.

Trust and felt trust also have different motivational outcomes (Skiba & Wildman, 2019), and felt trust may affect variables of interest through different pathways than trust itself (Salamon & Robinson, 2008). Felt trust has been less theoretically developed than trust and it is unclear when researchers should expect one to be important but not the other. While our results confirm the importance of trust in supervisors on overall team learning and subsequent team performance, we found no effect of felt trust on team learning or team performance. This is similar to other work on felt trust from supervisors in non-emergency teams, where supervisor felt trust did not contribute to group-level knowledge sharing (Nerstad et al., 2018). However, there are alternative pathways through which felt trust may affect team performance and team learning. For example, feeling trusted by coworkers and supervisors is associated with individual organizational citizenship behavior (Lau et al., 2014; Lester & Brower, 2003; Zheng et al., 2019). Further, other felt trust referents should be explored, such as felt trust from fellow team members or felt trust from subordinates.

4.4.2 Practical Implications

In general, the supervisor trust dyad is categorized by high trust. Respondents generally trusted their supervisors and felt trusted by them in turn. This is in line with previous qualitative work in Chapter 3, where participants were more readily able to recall functional, trusting relationships with their supervisors than distrustful relationships. However, trust is not universally high. Predictability is an important component of both trusting and feeling trusted by supervisors. Thus, it is perhaps unsurprising that respondents ordered as single resources, who

may not have been familiar with their supervisors before arriving on the incident, had lower levels of trust and felt trust than respondents who served repeatedly on the same team. When IMT members are familiar with each other, they are able to make decisions more accurately and quickly than ad hoc teams (Hayes, 2014). This is in line with our results; familiarity with supervisors increases trust in them, which enables greater team-level learning and subsequent team performance.

Trust is an important part of attending to information; in routine teams, members are more willing to share information with trusted team members (Chowdhury, 2005; Levin & Cross, 2004). In IMTs in particular, team members are more likely to use and assimilate technical information if it comes from trusted sources (McLennan et al., 2006; Rapp et al., 2020). Our results expand on this: trust in an individual, specifically one's supervisor, can also shape the overall learning environment. Supervisors seem to play a key role in shaping how team members relate to and interact with one another based on the example they set (Jahn & Black, 2017; Lewis et al., 2011). Perhaps unsurprisingly, the valued characteristics of good leaders in wildland fire and incident management (i.e., competency, personal genuineness, and integrity) also positively contribute to trust in supervisors (Waldron et al., 2015; Waldron & Schary, 2019). Indeed, although competence is important to develop trust in high risk, emergency situations (Colquitt et al., 2011), exemplary supervisors are categorized by their emotional and social intelligence (Boyatzis et al., 2017). Thus, supervisors with both interpersonal and operational skills may be key to foster flexible, adaptive, and effective overall team performance.

4.5 Limitations

Several limitations of this work warrant discussion. There are limitations based on the population sampled, survey design and item measurement, and analytical methods which

influence external and internal validity of this study. First, the research team was not able to survey employees working for the United States Forest Service (USFS). The research team submitted Freedom of Information Act (FOIA) requests for Department of Interior and USFS employee emails; the USFS FOIA request was rejected, and the subsequent appeal was rejected citing privacy concerns for the relevant employees. The research team also contacted USFS research scientists but were not able to get the contact information needed. More acres burn on USFS land than any other state or federal agency, and the USFS has thousands of employees working in fire management. The research team did not find any difference in variables of interest across the sampled agencies, but the external validity of these results to all of fire management are limited by the omission of the largest firefighting organization in the United States.

Next, some limitations are due to model design. As discussed previously, it is unclear from this data alone why benevolence is positively related to trust in supervisors, but felt benevolence is not related to felt trust from supervisors. Benevolence may not be an important component of subordinate trustworthiness. Alternatively, felt benevolence may not be an important component of felt trust, regardless of level of authority of the referent. To tease these apart, future models should include four trust referents: trust in supervisors, felt trust from supervisors, trust in subordinates, and felt trust from subordinates. This would allow a more holistic comparison of the antecedents of trustworthiness across types of trust and level of authority. Similarly, including all four trust referents would also provide a more nuanced understanding of the effect of trust and felt trust on team learning and team performance.

There are also limitations due to item measurement. Survey items measuring trustworthiness were designed based on the earlier qualitative work rather than existing scales

to measure trustworthiness. The goal was to design items more realistic to fire managers to reduce the chance of reactance and to improve construct validity. Except for predictability and felt predictability, most respondents selected “agree” or “strongly agree” for the trust, felt trust, trustworthiness, and felt trustworthiness items (corresponding to a 2 and 3 on a scale from – 3 to 3). This could be due to a variety of factors. It is likely the case that trust and felt trust are genuinely high in fire management. In the qualitative work respondents more readily recalled positive experiences than negative experiences. However, this may also indicate survey fatigue and/or low attention. Regardless, the outcome is highly skewed variables. To address this, variables were binned into three-level ordinal variables based on 33rd and 66th percentiles. However, this reduces variance. Using diagonally weighted least squares is an appropriate estimation method for ordinal variables but requires larger sample size than maximum likelihood methods to produce reliable estimates. This may contribute to why the model ultimately displayed only moderate fit.

Fit indices ranged from very poor (CFI) to good (SRMR). The modification indices recommended changes that were interesting, but not justifiable to add in post-hoc. In particular, the three largest changes recommended were to include a path predicting felt trust from supervisors from supervisor integrity (MI = 18.78), supervisor benevolence (MI = 14.72), and trust in supervisors (MI = 13.87). One could argue adding in these paths is in line with the internal process of determining felt trust through theories of lay reciprocity as described by Campagna and colleagues (2020). However, adding in these paths significantly improves model fit (CFI = .957, RMSEA = .033, SRMR = .047) but produces counterintuitive and atheoretical results. In the adjusted model, supervisor trust has a significant and negative effect on felt trust

from supervisors (β = -.450, p<.001) and felt trust from supervisors has a significant and negative effect on team learning behavior (β = -.175, p = .046).

4.6 Future Directions

Some of these limitations will be addressed in a follow-up study. The follow-up study will duplicate the items measured in this study but include items pertaining to trust in and felt trust from subordinates. The follow-up study includes more fire management personnel further down the chain of command in IMTs (e.g., single resource leaders and task force leaders) and 12 additional state-level agencies. The USFS will not be included in the follow-up study, but the expanded sample should provide a more holistic picture of the state of trust by including more agencies and positions. Additionally, with a larger sample, the model should have more power to account for the added complexity of the additional subordinate parameters. Items will likely need to be binned into ordinal-level variables again and the larger sample will also help provide more reliable estimates using diagonally weighted least squares estimation.

By surveying a larger and more diverse sample of individuals, we hope to also include the role of marginalized identities in giving and receiving trust. In the qualitative phase, women described their experiences receiving less trust than their male counterparts due to their gender. Although it was a goal of this research phase to analyze the effect of gender on trust in and felt trust from supervisors, the sample did not contain enough self-identifying women (4 respondents identified as women) for a reliable estimate. The follow-up study will also explore how ethnic and racial identity influence trust dynamics, which was absent in the first study.

There are several future directions for this work more broadly that are not the focus of the follow-up study. More work is needed to understand the behavioral outcomes of felt trust in

incident management. As discussed previously, felt trust from supervisors (and from subordinates) may affect team-level performance through a variety of mechanisms not explored here but discussed in the literature elsewhere. For example, felt trust may affect whether IMT members engage in organizational citizenship behavior, as is the case in non-emergency teams. Supporting risk management is of particular interest to wildland fire management professionals and researchers and it is an open question as to how trust influences risk-taking and risk tolerance. As well, this work parameterizes team performance very generally based on the respondents' perception of team performance; respondents are asked whether they believe the team "did a good job" and achieved their "team-level goals and objectives". Future work should consider different operationalizations of team performance, for example, overall tactic success, number of casualties, or team member attrition over time.

4.7 Conclusion

This study provides preliminary insight into the role of trust in and felt trust from supervisors in overall team learning and performance for wildland fire IMTs. Supervisors play an important role in the way team members communicate with each other; trust in supervisors is positively related to how much the team shares information and learns from one another. This in turn positively contributes to overall team performance. While felt trust from supervisors has played an important role in team performance for non-emergency teams such as those that work in private firms, we do not find evidence that felt trust from supervisors influences either team learning or team performance. Trust and felt trust, though similar, are not mirrored concepts of one another. While supervisor benevolence plays a significant role in whether respondents trust their supervisors, being perceived as benevolent does not seem to be important for feeling trusted by them. More work is needed to tease apart whether these

differences in trustworthiness characteristics and their subsequent effect on behavioral outcomes are due to differences in trust and felt trust as concepts, or differences in authority across trust referents.

Chapter 5. Conclusion: A Series of Research Briefs.

5.1 Research Brief 1: How Weather Forecasts Inform Tactical Decision-Making

5.1.1 Overview

Weather plays an integral role in fire management due to the direct and indirect effects it has on fire behavior. Firefighters and fire managers are accustomed to assimilating fire weather information in a range of forms and from a variety of sources. However, whether and how they use weather information likely depends on the perceived quality of the information and the decision strategies they employ. Given the importance of weather information to fire management decisions, it is critical to understand how weather data are used to ensure the best possible information is available when it is most needed. In this study, we examine how federal fire management officers use weather forecasts when deciding whether to directly or indirectly attack a fire 48 hours into an event.

5.1.2 Methods

We issued a survey with an embedded choice experiment to 182 Forest Service fire management officers on their confidence in and use of fire weather forecasts for tactical decision making. Respondents went through a series of choice sets where they had to make decisions about whether direct or indirect attack was preferable for an example fire given the time in season, fuel combustibility, wind, relative humidity, and precipitation forecasts.

5.1.3 Results and Implications

1) Importance of weather forecasts in tactical decision-making

How respondents used weather information depended on how the decision was framed. When respondents were told the initial strategy in the first 48 hours was to *indirectly* attack the

fire and they would have to decide whether to switch to *direct* attack, the most important piece of information was time in season, followed by wind forecasts. However, when respondents were told the strategy in the first 48 hours was to *directly* attack the fire and they would have to decide whether to switch to *indirect* attack, the most important piece of information was precipitation, followed by time in season. Regardless of how the choice was framed, respondents preferred direct attack for fires early in the season with moderate fire behavior and preferred indirect attack for fires later in the season with extreme fire behavior. These results indicate that weather forecasts are not interpreted consistently across decision-makers. Rather, what information fire managers use and what they learn from it depends on the context; weather information does not exist in a vacuum.

2) Confidence in weather forecast models

Respondents tended to have moderate to high confidence in weather models broadly and wind, humidity, and precipitation models specifically. However, respondents had lower confidence in precipitation and wind forecasts than relative humidity or weather forecasts in general. Wind and precipitation forecasts were the most important pieces of weather information in the choice experiment. We suggest prioritizing efforts to improve the forecast accuracy of these variables where possible and increase confidence in the resulting forecast as appropriate.

3) Supporting fire manager decision-making

Fire managers work in uncertain and time-pressured environments where they must make choices about how much information to consider and how much to deliberate on that information before they act. Tools to support better risk management, including weather forecasts, will be more effective when designed with the decision strategies of fire managers in

mind, either by supporting fast, heuristic, or intuitive decision-making or by debiasing and encouraging more deliberative decision-making. To support heuristic decision-making, tools should provide reliable decision rules that enable quick, "good enough" decision-making (e.g., switch to direct attack once the probability of wetting rain reaches a certain threshold). To support deliberative decision-making, tools should simplify and summarize information and mitigate known challenges in decision making among managers, such as the tendency to continue with the current strategy (i.e, a status quo bias).

Table 5. 1 Relative importance of the weather attributes across experimental conditions.

	Condition 1: Indirect to Direct Attack	Condition 2: Direct to Indirect Attack
Seasonality	37.4	23.15
Wind	19.31	12.44
Precipitation	18.74	31.46
Energy Release Component	16.15	21.97
Relative Humidity	8.41	10.97

5.1.4 Management Implications

- Weather is a key driver of fire behavior and fire managers readily adapt their tactics given weather forecasts.
- How fire managers interpret and use weather information depends on the context, including what tactics are currently being used on the fire.

- Broadly speaking, fire managers prefer direct attack early in the season or with moderate fire behavior and prefer indirect attack later in the season or with extreme fire behavior.
- Precipitation and wind forecasts are important drivers of tactical decision-making but fire managers are less confident in these forecasts than relative humidity models or weather forecasts generally.

5.2 Research Brief 2: Rapidly Assessing Trust on the Fire Line

5.2.1 Overview

Trust is a critical component of working in incident management teams (IMTs). Individuals must trust their team members and their team members must in turn trust them to ensure sustained and coordinated decision-making. Because fires are fast-paced and dynamic environments, individuals may need to make conclusions about trustworthiness before they see their team member perform. These rapid initial assessments may be based wholly or in part on cultural symbols and cues of competence. In this study, we examined what cues IMT members use to rapidly assess the trustworthiness of their supervisors and direct reports. We also examined what cues IMT members believe their supervisors and direct reports use to assess the IMT member's trustworthiness.

5.2.2 Methods

We interviewed 27 fire managers serving in the upper-to-mid levels of IMT, including division supervisors, operation section chiefs, and incident commanders. In the interviews, we asked respondents what trustworthiness characteristics 1) they look for in supervisors, 2) they look for in direct reports 3) they believe their supervisors look for in them, and 4) they believe their direct reports look for in them. Interviews were coded based on a codebook developed from guiding theory and emerging themes within the interviews.

5.2.3 Results and Implications

Respondents explained when arriving on a fire, there is an initial proving period where team members try to rapidly assess each other's competence, skills, and abilities. In some cases, respondents would give their direct reports a baseline level of trust by virtue of their qualification- for example, the act of going through a task book and receiving the designation of

"division supervisor" could be enough for a respondent to assume a direct report was a competent division supervisor. However, that implicit trust was usually not extended to any other trust referent.

Across the four trust referents, a series of generally accepted symbols of competence emerged. Respondents either used these symbols to judge their peers, believed they would be judged by them, or both. These symbols were often tied to group membership or previous professional experience. For example, hotshots were assumed to be more competent than other types of crews. Thus, a supervisor who had served as a hotshot was often given more credibility. Consequently, team members would look for and wear hotshot clothing, such as a patch or belt buckle. Similarly, team members would assess one another based on their day job and home region. Because of the nature of fire activity, specific regions of the United States may carry a stigma; respondents indicated team members from the Midwest or South may be perceived as less capable than team members from the West or Southwest.

Physical appearance was a commonly used cue to assess trustworthiness. Individuals who fit the cultural stereotype for firefighter, i.e., tall, masculine, and stoic, were both implicitly and explicitly assumed to be more capable than team members who did not fit that mold, particularly women. Women described that because of their gender, they had to go above and beyond what their male colleagues had to do to prove they earned their certification and secure the trust of their fellow team members. It is important to interrogate whether the physical cues used to assess competence and trustworthiness are indeed valid signals of the traits valued in mid-to-upper level IMT members, which include communication skills, concern for firefighter safety and well-being, and inclusive leadership.

5.2.4 Management Implications

- Because of the pace of fire events, the initial size-up period is critical for establishing trust between team members. First impressions are very impactful.
- During initial size-up, IMT members use a variety of shorthand symbols or cues to judge one another. IMT members are generally aware of them and may strategically leverage them to earn trust and prove competence.
- Although commonly used, cues based on physical appearance may not be reliable indicators of the kinds of skills valued in mid-to-upper IMT positions.
- During initial size-up, team members may get more reliable information by using brief resumes and/or short question and answer sessions rather than relying on physical cues.

5.3 Research Brief 3: Earning Trust as a Supervisor

5.3.1 Overview

Supervisors play an important role in shaping how well incident management teams (IMTs) perform. Supervisors can foster communication and information sharing among their subordinates by creating an environment where subordinates feel comfortable speaking up, asking questions, and sharing information with one another. Because communication and the exchange of information is critical to maintain a shared understanding of the fire and coordinated action, supervisors can influence how the team performs outside of their immediate direct reports. Thus, it is critically important that subordinates feel they can trust their supervisors, and supervisors embody trustworthy characteristics. In this study, we examine what skills and characteristics IMT members believe are important for trustworthy supervisors.

5.3.2 Methods

We interviewed 27 fire managers serving in the upper-to-mid levels of IMTs, including division supervisors, operation section chiefs, and incident commanders. In the interviews, we asked respondents what trustworthiness characteristics 1) they look for in supervisors, and 2) they believe their subordinates look for in them. Interviews were coded based on guiding theory and emerging themes within the interviews.

5.3.3 Results and Implications

Although trust is generally high on IMTs, respondents indicated that supervisors are not granted automatic trust, but instead must earn it by displaying a variety of characteristics. These characteristics can be grouped into three categories, in order of most frequently mentioned to least frequently mentioned. Supervisors can better earn trust from their direct reports by cultivating the following characteristics.

1) Skills and Competencies

According to respondents, supervisors need to first and foremost be operationally sound. Supervisors need to plan safe and effective tactics and consider contingencies while being able to adapt to new information. Communication skills are also critical. IMT members value supervisors who can explain their plans, goals, and rationale clearly and effectively. Respondents indicated communication skills require more than public speaking; it also includes knowing when to listen. Finally, respondents are aware when they act as supervisors, their direct reports want them to display leadership skills, including confidence, decisiveness, composure, and professionalism.

2) Benevolence and Concern

It is important for supervisors to express genuine care and concern for the individuals they supervise and on-the-ground firefighters. For example, incident commanders and operations section chiefs who were perceived as apathetic or uncaring about on-the-ground firefighters were distrusted by other IMT members. Respondents also believed trustworthy supervisors granted their subordinates decision-making autonomy and did not micromanage. They also actively included direct reports in decision-making and planning by soliciting their input. For example, some respondents made a point of treating their direct reports as equals and not subordinates and including single resources and new members in decision-making.

3) Principles and Values

Respondents valued supervisors who communicated not only clearly and effectively, but honestly. Respondents expected supervisors to not be disingenuous when discussing the feasibility and risk associated with a proposed plan. Similarly, according to respondents, it is

important for supervisors to act with humility, and admit their own limits in terms of skills and knowledge. There are cultural ideas of the right and wrong reasons to be in fire management, and supervisors who were perceived as too interested in money, influence, or external praise were distrusted. On the flip side, supervisors who took ownership of bad decisions or outcomes, described as not throwing direct reports under the bus or having the buck stop with them, were trustworthy.

Table 5. 2 Importance of Characteristics According to Respondents

	Trust in Supervisors (n = 21)	Felt Trust from Subordinates (n = 24)
Skill and Competencies	**91%**	**92%**
Operationally sound decision-making	🟨	🟩
Communication skills	🟩	🟩
Leadership	🟨	🟩
Benevolence and Concern	**74%**	**77%**
Care and concern for firefighters	🟩	🟨
Collaborative and inclusive leadership	🟨	🟨
Giving decision-making authority	🟨	🟨
Principles and Values	**74%**	**46%**
Honest Communication	🟨	🟩
Personal Humility	🟨	🟥
Owning Decisions	🟩	🟨

= one-third or fewer of respondents who discussed the primary attribute described it with the characteristic

= more than one third and up to two-thirds of respondents who discussed the primary attribute described it with the characteristic

= more than two-thirds of respondents who discussed the primary attribute described it with the characteristic.

5.3.4 Management Implications

- There are two steps to developing trustworthiness: team members must embody trustworthy characteristics, and these trustworthy characteristics must be recognized by subordinates
- Operationally sound decision-making is only one component of trustworthiness; it is important for supervisors to also show care and concern for their direct reports and be honest about their shortcomings.
- Communication skills are critical for earning trust: they are valuable outright and better enable supervisors to communicate other trust characteristics, such as inclusive leadership.
- Professional development opportunities should be offered to cultivate the key operational skills of a trustworthy supervisor, including long-term planning and risk management.

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Appendix A: Chapter 2 Survey

Chapter 2 Survey: JFSP Fire Weather Choice Experiment and Survey

SurveyIntro

Throughout this survey, you will be asked a variety of questions relating to wildfire management. We recognize wildfire management is a complex process and decisions are often context-specific based on many interdependent factors. By necessity, the scenarios you will encounter in this survey will be simplified versions of the choices fire management professionals make.

Please respond to each question to the best of your ability by selecting the response that most closely aligns with your expected decision in each situation.

It is best if you complete the survey in one setting. That being said, if you think you may have to complete it in multiple sessions (coming back to it over the course of a day or days), PLEASE DO NOT EXIT THIS BROWSER. If the browser accidentally closes, and/or an error occurs where you can't pick up where you let off, please contact the research team at FireSurvey@osu.edu

In this next section, we will ask you questions relating to tactical decisions and the factors that inform them. We will first introduce a wildfire event.

Please read the following section carefully.

---Page Break---

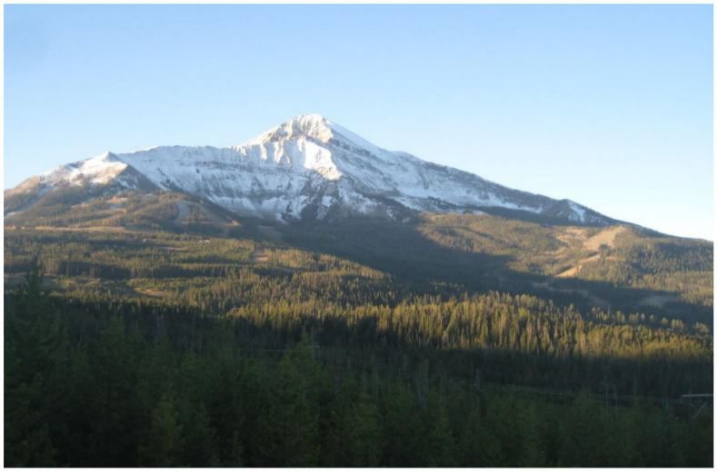
Imagine the following event:

A lightning-ignited fire is burning in **mixed conifer** and has escaped initial attack and overwhelmed initial resources. The fire is currently **150 acres** and is being managed as a **Type 3 event** and **you are the most qualified individual** (for example, ICT3 or DIVS) arriving on the incident. **It is an average fire season in the area where the fire is occuring**, and you may or may not get more resources if you request them. Pictures of the general area have been provided below. You have requested short-term fire behavior analysis and a spot weather forecast. **You are 48 hours into the event**, it is early morning, the nearest primary care center is less than an hour away, and there have been no "incidents within the incident".

Your local **planning documents** allow you to **manage fire**. The **public** has mixed feelings; while **some dislike fire** and favor suppression, **others understand the ecological role of fire** and are more tolerant of non-suppression tactics. **The nearest community is ten miles away** from where the fire started.

The fire is burning in **moderate terrain with snag potential**. While there are areas to directly engage with an anchor point, weak trees may be present. The area of indirect attack features roads about a mile away and ridges between 0.5 – 1.5 miles away from the fire perimeter.

Pictures of the general area:



Imagine you had to decide whether you would directly or indirectly attack this fire.

In your opinion, based on the limited information provided, which strategy is preferable?

ScenarioConfidence=1 ○ **Direct** attack is **much more preferable** than indirect attack

ScenarioConfidence=2 ○ **Direct** attack is **somewhat more preferable** than indirect attack

ScenarioConfidence=3 ○ **Neither** direct nor indirect attack is preferable

ScenarioConfidence=4 ○ **Indirect** attack is **somewhat more preferable** than direct attack

ScenarioConfidence=5 ○ **Indirect** attack is **much more preferable** than direct attack

--Page Break—

[Respondents randomly assigned to one of two conditions:

1. Condition 1: The initial attack went direct, respondents will choose whether to go indirect
2. Condition 2: The initial attack went indirect, respondents will choose whether to go direct]

[Condition 1 Branch Questions]

LocalTeamDA

For the first 48 hours of the fire event, the local team's strategy has been to **directly attack** the fire.

Based on the information provided about the fire, to what extent do you agree with the decision to **directly attack** during the first 48 hours?

LocalTeamDA=1 Strongly disagree

LocalTeamDA=2 Somewhat disagree

LocalTeamDA=3 Neither agree nor disagree

LocalTeamDA=4 Somewhat agree

LocalTeamDA=5 Strongly agree

DAWhy

Please briefly explain your answer.

--Page Break--

TransitiontoCEDA1

While the information we previously provided about the fire event will remain unchanged (i.e., the fire is 150 acres in mixed conifer, being managed as a Type 3 event, etc.), we will now provide you with additional information that will vary across multiple sets of scenarios.

We are interested in knowing under what scenario you would be most likely to change the strategy and **indirectly attack** the fire given what you know now. Each time you make a decision, we will provide the baseline conditions as a reminder as you consider whether the new conditions merit a change in strategy.

If you would **indirectly attack** more than one of these fires, please select the one you think is **most appropriate for indirect attack**.

You will complete this exercise 9 times before moving on to the rest of the survey. We estimate this section should take 10 - 15 minutes to complete.

--Page Break—

[Respondents assigned to this condition would then see 9 randomized choice sets. Example choice set below]

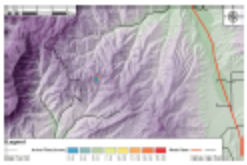
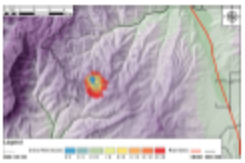
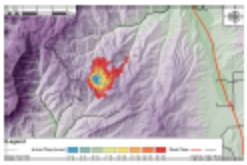
Click here to expand and collapse the original baseline information about the event

REMINDER: The strategy up to this point has been to **directly attack** this fire.

Please indicate for which of the following scenarios you would be most likely to change the strategy and **indirectly attack** the fire.

If you would **indirectly attack** more than one of these fires, please select the one you think is **most appropriate for indirect attack**.

(1 of 9)
If you see a blank page, the choice sets may take a moment to load. We appreciate your patience.

	 Click here for larger image in a new window	 Click here for larger image in a new window	 Click here for larger image in a new window
Forecasted Wind	Very windy	Slightly windy	Slightly windy
Forecasted Humidity	Humid	Dry	Moderate
Forecasted Precipitation	High probability of wetting rain	No rain forecasted	No rain forecasted
Time in fire season	Early	Early	Late
Energy release component (ERC)	Trending downwards toward 60%	Stable around 80%	Trending upwards toward 90%
	cbcDA_Random1 Select	cbcDA_Random1 Select	cbcDA_Random1 Select

NONE: I would only **directly attack ALL OF** these fires

cbcDA_Random1 Select

--Page Break—

[Condition 2 Branch Questions]

LocalTeamIA

For the first 48 hours of the fire event, the local team's strategy has been to **indirectly attack** the fire.

Based on the information provided about the fire, to what extent do you agree with the decision to **indirectly attack** during the first 48 hours?

LocalTeamIA=1 ○ Strongly disagree

LocalTeamIA=2 ○ Somewhat disagree

LocalTeamIA=3 ○ Neither agree nor disagree

LocalTeamIA=4 ○ Somewhat agree

LocalTeamIA=5 ○ Strongly agree

IAWhy

Please briefly explain your answer.

--Page Break—

TransitiontoCEIA1

While the information we previously provided about the fire event will remain unchanged (i.e., the fire is 150 acres in mixed conifer, being managed as a Type 3 event, etc.), we will now provide you with additional information that will vary across multiple sets of scenarios.

We are interested in knowing under what scenario you would be most likely to change the strategy and **directly attack** the fire given what you know now. Each time you make a decision, we will provide the baseline conditions as a reminder as you consider whether the new conditions merit a change in strategy.

If you would **directly attack** more than one of these fires, please select the one you think is **most appropriate for direct attack.**

You will complete this exercise 9 times before moving on to the rest of the survey. We estimate this section should take 10 - 15 minutes to complete.

--Page Break—

[Respondents assigned to this condition would then see 9 randomized choice sets. Example choice set below]

--Page Break—

cbcIA_Random1

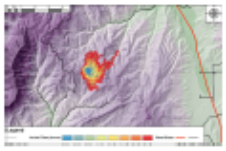
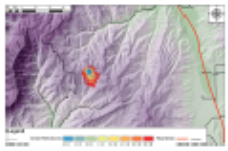
Click here to expand and collapse the original baseline information about the event

The strategy up to this point has been to **indirectly attack** this fire.

Please indicate for which of the following scenarios you would be most likely to change the strategy and **directly attack** the fire.

If you would **directly attack** more than one of these fires, please select the one you think is **most appropriate for direct attack**.

(1 of 9)
If you see a blank page, the choice sets may take a moment to load. We appreciate your patience.

	 Click here for larger image in a new window	 Click here for larger image in a new window	 Click here for larger image in a new window
Forecasted Precipitation	No rain forecasted	No rain forecasted	High probability of wetting rain
Forecasted Humidity	Moderate	Humid *	Dry
Forecasted Wind	Slightly windy	Slightly windy	Windy
Time in fire season	Early	Middle	Late
Energy release component (ERC)	Trending upwards toward 90%	Stable around 80%	Trending downwards toward 60%
	cbcIA_Random1 Select	cbcIA_Random1 Select	cbcIA_Random1 Select

NONE: I would only **indirectly attack ALL OF** these fires

cbcIA_Random1

Select

--Page Break—

[All respondents saw the rest of the survey questions]

ImportantFactors

Thinking broadly about the options you were presented with, what were the main factors that weighed into your decisions? Please describe them briefly.

WhereFire1

Fire managers often draw on previous experience at specific locations when making decisions. When thinking about the wildfire event described to you, if you compared it to another fire or imagined the fire was in a particular location, please describe where that was. Otherwise, please answer "none".

--Page Break—

ForecastIntro

Thank you for completing the choice experiment. We estimate the remainder of the survey should take approximately 10-15 minutes to complete.

Please answer the following questions as it relates to your opinions about **3-day forecasts** for each weather factor.

ForecastConfidenceGen1

In your opinion, how reliable are **weather forecasts overall**? Would you say they are accurate...

ForecastConfidenceGen1=1 ○ 0 - 24% of the time

ForecastConfidenceGen1=2 ○ 25 - 50% of the time

ForecastConfidenceGen1=3 ○ 51 - 75% of the time

ForecastConfidenceGen1=4 ○ 76 - 100% of the time

ForecastConfidenceWin1

In your opinion, how reliable are **wind forecasts**? Would you say they are accurate...

ForecastConfidenceWin1=1 ○ 0 - 24% of the time

ForecastConfidenceWin1=2 ○ 25 - 50% of the time

ForecastConfidenceWin1=3 ○ 51 - 75% of the time

ForecastConfidenceWin1=4 ○ 76 - 100% of the time

ForecastConfidencePre1

In your opinion, how reliable are **precipitation forecasts**? Would you say they are accurate...

ForecastConfidencePre1=1 ○ 0 - 24% of the time

ForecastConfidencePre1=2 ○ 25 - 50% of the time

ForecastConfidencePre1=3 ○ 51 - 75% of the time

ForecastConfidencePre1=4 ○ 76 - 100% of the time

ForecastConfidenceHum1

In your opinion, how reliable are **humidity forecasts**? Would you say they are accurate...

ForecastConfidenceHum1=1 ○ 0 - 24% of the time

ForecastConfidenceHum1=2 ○ 25 - 50% of the time

ForecastConfidenceHum1=3 ○ 51 - 75% of the time

ForecastConfidenceHum1=4 ○ 76 - 100% of the time

--Page Break—

TacticPressure1

When thinking about the culture of the Forest Service, do you believe this culture encourages managers and firefighters to directly or indirectly attack fires?

TacticPressure1=1 Strongly encourages **direct** attack

TacticPressure1=2 Moderately encourages **direct** attack

TacticPressure1=3 Somewhat encourages **direct** attack

TacticPressure1=4 Does not encourage a specific strategy

TacticPressure1=5 Somewhat encourages **indirect** attack

TacticPressure1=6 Moderately encourages **indirect** attack

TacticPressure1=7 Strongly encourages **indirect** attack

TacticRiskiness1

Consider the relative riskiness of direct attack and indirect attack for firefighter safety. Some people believe directly attacking a fire early is less risky, because while direct attack creates greater safety concerns for firefighters, the overall number exposed is lower. Others believe indirectly attacking a fire is less risky, because while indirect attack creates fewer safety concerns, the overall number exposed is greater.

In your opinion, generally speaking, which strategy is **more risky for firefighter safety**?

TacticRiskiness1=1 **Directly attacking** is much riskier than indirectly attacking

TacticRiskiness1=2 **Directly attacking** is somewhat riskier than indirectly attacking

TacticRiskiness1=3 Direct attack and indirect attack are **equally risky**

TacticRiskiness1=4 **Indirectly attacking** is somewhat riskier than directly attacking

TacticRiskiness1=5 **Indirectly attacking** is much riskier than directly attacking

--Page Break—

SortMostImportant

Wildfire management decisions are obviously very complex and prone to influence from many different factors both within your control and outside your control. Assuming a wildfire has occurred, what are the **first 3 things you think about** when trying to decide whether to directly or indirectly attack the fire?

Please choose the **first 3 important pieces of information** that you consider when deciding to directly or indirectly attack a fire.

- SortMostImportant_4 ☐ Availability of tactical resources
- SortMostImportant_3 ☐ Local public and political climate
- SortMostImportant_10 ☐ Dynamics between incident command and the local unit
- SortMostImportant_5 ☐ Time in season (seasonality)
- SortMostImportant_9 ☐ Threats to firefighter safety
- SortMostImportant_6 ☐ Presence of WUI (e.g., people, homes, and structures)
- SortMostImportant_2 ☐ Requirements of federal environmental policy (e.g., ESA, NEPA, etc.)
- SortMostImportant_8 ☐ Short-term (3-day) weather forecasts
- SortMostImportant_7 ☐ Current weather conditions
- SortMostImportant_11 ☐ Ability to coordinate across managing agencies (e.g., federal, state)
- SortMostImportant_1 ☐ Federal wildland fire management guidance (e.g., Cohesive Strategy, 2009 Implementation Guidance, etc.)
- SortMostImportant_12 ☐ SortMostImportant_12_other Other

MostImportantWhy

Please briefly explain why you selected these 3 factors.

--Page Break—

IntroModelUse

We are now going to ask you a series of questions about how you use wildfire decision support tools.

Wildfire decision support tools such as Fire Area Simulator (FARSITE), Wildland Fire Decision Support System (WFDSS), Fire Spread Probability (FSPRO), National Fire Danger Rating System (NFDRS) and others may be used in multiple ways on a fire event. For example, these tools may be used to project future conditions, assess recent fire growth, and/or document previous decisions.

Consider your experiences on wildfire events where **information from wildfire decision support tools was available to you.**

ModelUse1

In past experiences how often have you used information from wildfire decision support tools **to project future conditions so that you could update strategies and tactics?**

ModelUse1=1 ○ 1 Never

ModelUse1=2 ○ 2 Rarely

ModelUse1=3 ○ 3 Sometimes

ModelUse1=4 ○ 4 About half the time

ModelUse1=5 ○ 5 Often

ModelUse1=6 ○ 6 Almost always

ModelUse1=7 ○ 7 Always

ModelUse2

In past experiences how often have you used information from wildfire decision support tools **to assess recent fire growth and tactic effectiveness to date?**

- ModelUse2=1 1 Never
- ModelUse2=2 2 Rarely
- ModelUse2=3 3 Sometimes
- ModelUse2=4 4 About half the time
- ModelUse2=5 5 Often
- ModelUse2=6 6 Almost always
- ModelUse2=7 7 Always

ModelUse3

In past experiences how often have you used information from wildfire decision support tools **to document decisions that had already been made?**

- ModelUse3=1 1 Never
- ModelUse3=2 2 Rarely
- ModelUse3=3 3 Sometimes
- ModelUse3=4 4 About half the time
- ModelUse3=5 5 Often
- ModelUse3=6 6 Almost always
- ModelUse3=7 7 Always

ModelUse4

In past experiences how often have you used information from wildfire decision support tools **to compare your intuition and model predictions as events progress?**

ModelUse4=1 1 Never

ModelUse4=2 2 Rarely

ModelUse4=3 3 Sometimes

ModelUse4=4 4 About half the time

ModelUse4=5 5 Often

ModelUse4=6 6 Almost always

ModelUse4=7 7 Always

--Page Break—

BelowTrustIntro

For this next section, consider your role on incident management teams (e.g., ICT3, DIVS, etc.). The first set of questions have to do with what you think about **those with LESS authority than you within the fire chain of command** when it comes to wildfire management.

Please indicate the extent to which you agree or disagree with the following statements.

--Page Break—

BelowTrustIntro1

Consider your role on incident management teams (e.g., ICT3, DIVS, etc.). The following questions have to do with what you think about **those with LESS authority than you within the fire chain of command** when it comes to wildfire management.

Please indicate the extent to which you agree or disagree with the following statements.

BelowAbil1

Those with less authority than me are **very capable of performing their jobs**.

BelowAbil1=1 ○ 1. Strongly disagree

BelowAbil1=2 ○ 2. Disagree

BelowAbil1=3 ○ 3. Somewhat disagree

BelowAbil1=4 ○ 4. Neither agree nor disagree

BelowAbil1=5 ○ 5. Somewhat agree

BelowAbil1=6 ○ 6. Agree

BelowAbil1=7 ○ 7. Strongly agree

BelowBenev1

Those with less authority **care about me**.

BelowBenev1=1 1. Strongly disagree

BelowBenev1=2 2. Disagree

BelowBenev1=3 3. Somewhat disagree

BelowBenev1=4 4. Neither agree nor disagree

BelowBenev1=5 5. Somewhat agree

BelowBenev1=6 6. Agree

BelowBenev1=7 7. Strongly agree

I **never have to wonder** whether those with less authority than me **will stick to their word**.

BelowInteg1=1 1. Strongly disagree

BelowInteg1=2 2. Disagree

BelowInteg1=3 3. Somewhat disagree

BelowInteg1=4 4. Neither agree nor disagree

BelowInteg1=5 5. Somewhat agree

BelowInteg1=6 6. Agree

BelowInteg1=7 7. Strongly agree

BelowTrust2

I am willing to rely on the work-related judgments of those with less authority than me.

- BelowTrust2=1 ○ 1. Strongly disagree
- BelowTrust2=2 ○ 2. Disagree
- BelowTrust2=3 ○ 3. Somewhat disagree
- BelowTrust2=4 ○ 4. Neither agree nor disagree
- BelowTrust2=5 ○ 5. Somewhat agree
- BelowTrust2=6 ○ 6. Agree
- BelowTrust2=7 ○ 7. Strongly agree

BelowTrust4

I am **willing to discuss problems or difficulties that could potentially be used to disadvantage me** with those who have less authority.

- BelowTrust4=1 ○ 1. Strongly disagree
- BelowTrust4=2 ○ 2. Disagree
- BelowTrust4=3 ○ 3. Somewhat disagree
- BelowTrust4=4 ○ 4. Neither agree nor disagree
- BelowTrust4=5 ○ 5. Somewhat agree
- BelowTrust4=6 ○ 6. Agree
- BelowTrust4=7 ○ 7. Strongly agree

BelowInteg3

Sound principles seem to guide the behavior of those with less authority than me.

BelowInteg3=1 1. Strongly disagree

BelowInteg3=2 2. Disagree

BelowInteg3=3 3. Somewhat disagree

BelowInteg3=4 4. Neither agree nor disagree

BelowInteg3=5 5. Somewhat agree

BelowInteg3=6 6. Agree

BelowInteg3=7 7. Strongly agree

--Page Break—

BelowTrustIntroContd

Continuing to think about **those with LESS authority than you,** please indicate the extent to which you agree or disagree with the following statements.

BelowBenev3

Those with less authority will **go above and beyond to help me do my job**.

BelowBenev3=1 1. Strongly disagree

BelowBenev3=2 2. Disagree

BelowBenev3=3 3. Somewhat disagree

BelowBenev3=4 4. Neither agree nor disagree

BelowBenev3=5 5. Somewhat agree

BelowBenev3=6 6. Agree

BelowBenev3=7 7. Strongly agree

BelowAbil3

Those with less authority than me are **well qualified for their positions**.

BelowAbil3=1 1. Strongly disagree

BelowAbil3=2 2. Disagree

BelowAbil3=3 3. Somewhat disagree

BelowAbil3=4 4. Neither agree nor disagree

BelowAbil3=5 5. Somewhat agree

BelowAbil3=6 6. Agree

BelowAbil3=7 7. Strongly agree

BelowInteg2

I **hold similar values** to those with less authority than me.

BelowInteg2=1 1. Strongly disagree

BelowInteg2=2 2. Disagree

BelowInteg2=3 3. Somewhat disagree

BelowInteg2=4 4. Neither agree nor disagree

BelowInteg2=5 5. Somewhat agree

BelowInteg2=6 6. Agree

BelowInteg2=7 7. Strongly agree

BelowTrust1

I can rely on those with less authority **to back me up in difficult situations**.

BelowTrust1=1 ○ 1. Strongly disagree

BelowTrust1=2 ○ 2. Disagree

BelowTrust1=3 ○ 3. Somewhat disagree

BelowTrust1=4 ○ 4. Neither agree nor disagree

BelowTrust1=5 ○ 5. Somewhat agree

BelowTrust1=6 ○ 6. Agree

BelowTrust1=7 ○ 7. Strongly agree

BelowTrust3

I can discuss how I honestly feel about work, **even negative feelings and frustration,** with those who have less authority than me.

BelowTrust3=1 ○ 1. Strongly disagree

BelowTrust3=2 ○ 2. Disagree

BelowTrust3=3 ○ 3. Somewhat disagree

BelowTrust3=4 ○ 4. Neither agree nor disagree

BelowTrust3=5 ○ 5. Somewhat agree

BelowTrust3=6 ○ 6. Agree

BelowTrust3=7 ○ 7. Strongly agree

BelowBenev2

My goals for the fire event are very important to those with less authority than me.

BelowBenev2=1 1. Strongly disagree

BelowBenev2=2 2. Disagree

BelowBenev2=3 3. Somewhat disagree

BelowBenev2=4 4. Neither agree nor disagree

BelowBenev2=5 5. Somewhat agree

BelowBenev2=6 6. Agree

BelowBenev2=7 7. Strongly agree

BelowAbil2

Those with less authority than me have a lot of **knowledge about how to respond to fire** under a variety of conditions and circumstances.

BelowAbil2=1 1. Strongly disagree

BelowAbil2=2 2. Disagree

BelowAbil2=3 3. Somewhat disagree

BelowAbil2=4 4. Neither agree nor disagree

BelowAbil2=5 5. Somewhat agree

BelowAbil2=6 6. Agree

BelowAbil2=7 7. Strongly agree

--Page Break—

AboveTrustIntro

Continuing to think about your role on incident management teams (e.g., ICT3, DIVS, etc.), now think about **those with <u>MORE</u> authority than you within the fire chain of command** when it comes to wildfire management.

Please indicate the extent to which you agree or disagree with the following statements.

--Page Break—

AboveTrustIntro1

Continuing to think about your role on incident management teams (e.g., ICT3, DIVS, etc.), now think about **those with <u>MORE</u> authority than you within the fire chain of command** when it comes to wildfire management.

Please indicate the extent to which you agree or disagree with the following statements.

AboveAbil1

Those with more authority than me are **very capable of performing their jobs**.

- AboveAbil1=1 ○ 1. Strongly disagree
- AboveAbil1=2 ○ 2. Disagree
- AboveAbil1=3 ○ 3. Somewhat disagree
- AboveAbil1=4 ○ 4. Neither agree nor disagree
- AboveAbil1=5 ○ 5. Somewhat agree
- AboveAbil1=6 ○ 6. Agree
- AboveAbil1=7 ○ 7. Strongly agree

AboveAbil3

Those with more authority than me are **well qualified for their positions**.

AboveAbil3=1 ○ 1. Strongly disagree

AboveAbil3=2 ○ 2. Disagree

AboveAbil3=3 ○ 3. Somewhat disagree

AboveAbil3=4 ○ 4. Neither agree nor disagree

AboveAbil3=5 ○ 5. Somewhat agree

AboveAbil3=6 ○ 6. Agree

AboveAbil3=7 ○ 7. Strongly agree

AboveInteg3

Sound principles seem to guide the behavior of those with more authority than me.

AboveInteg3=1 ○ 1. Strongly disagree

AboveInteg3=2 ○ 2. Disagree

AboveInteg3=3 ○ 3. Somewhat disagree

AboveInteg3=4 ○ 4. Neither agree nor disagree

AboveInteg3=5 ○ 5. Somewhat agree

AboveInteg3=6 ○ 6. Agree

AboveInteg3=7 ○ 7. Strongly agree

AboveTrust4

I am **willing to discuss problems or difficulties that could potentially be used to disadvantage me** with those who have more authority.

- AboveTrust4=1 1. Strongly disagree
- AboveTrust4=2 2. Disagree
- AboveTrust4=3 3. Somewhat disagree
- AboveTrust4=4 4. Neither agree nor disagree
- AboveTrust4=5 5. Somewhat agree
- AboveTrust4=6 6. Agree
- AboveTrust4=7 7. Strongly agree

AboveBenev2

My goals for the fire event are very important to those with more authority than me.

- AboveBenev2=1 1. Strongly disagree
- AboveBenev2=2 2. Disagree
- AboveBenev2=3 3. Somewhat disagree
- AboveBenev2=4 4. Neither agree nor disagree
- AboveBenev2=5 5. Somewhat agree
- AboveBenev2=6 6. Agree
- AboveBenev2=7 7. Strongly agree

AboveInteg2

I **hold similar values** to those with more authority than me.

AboveInteg2=1 1. Strongly disagree

AboveInteg2=2 2. Disagree

AboveInteg2=3 3. Somewhat disagree

AboveInteg2=4 4. Neither agree nor disagree

AboveInteg2=5 5. Somewhat agree

AboveInteg2=6 6. Agree

AboveInteg2=7 7. Strongly agree

--Page Break—

AboveTrustIntroContd

Continuing to think about **those with MORE authority than you,** please indicate the extent to which you agree or disagree with the following statements.

AboveBenev1

Those with more authority **care about me**.

AboveBenev1=1 1. Strongly disagree

AboveBenev1=2 2. Disagree

AboveBenev1=3 3. Somewhat disagree

AboveBenev1=4 4. Neither agree nor disagree

AboveBenev1=5 5. Somewhat agree

AboveBenev1=6 6. Agree

AboveBenev1=7 7. Strongly agree

AboveInteg1

I **never have to wonder** whether those with more authority than me **will stick to their word**.

- AboveInteg1=1 ○ 1. Strongly disagree
- AboveInteg1=2 ○ 2. Disagree
- AboveInteg1=3 ○ 3. Somewhat disagree
- AboveInteg1=4 ○ 4. Neither agree nor disagree
- AboveInteg1=5 ○ 5. Somewhat agree
- AboveInteg1=6 ○ 6. Agree
- AboveInteg1=7 ○ 7. Strongly agree

AboveAbil2

Those with more authority than me have a lot of **knowledge about how to respond to fire** under a variety of conditions and circumstances.

- AboveAbil2=1 ○ 1. Strongly disagree
- AboveAbil2=2 ○ 2. Disagree
- AboveAbil2=3 ○ 3. Somewhat disagree
- AboveAbil2=4 ○ 4. Neither agree nor disagree
- AboveAbil2=5 ○ 5. Somewhat agree
- AboveAbil2=6 ○ 6. Agree
- AboveAbil2=7 ○ 7. Strongly agree

AboveTrust1

I can rely on those with more authority **to back me up in difficult situations**.

AboveTrust1=1 1. Strongly disagree

AboveTrust1=2 2. Disagree

AboveTrust1=3 3. Somewhat disagree

AboveTrust1=4 4. Neither agree nor disagree

AboveTrust1=5 5. Somewhat agree

AboveTrust1=6 6. Agree

AboveTrust1=7 7. Strongly agree

AboveBenev3

Those with more authority will **go above and beyond to help me do my job**.

AboveBenev3=1 1. Strongly disagree

AboveBenev3=2 2. Disagree

AboveBenev3=3 3. Somewhat disagree

AboveBenev3=4 4. Neither agree nor disagree

AboveBenev3=5 5. Somewhat agree

AboveBenev3=6 6. Agree

AboveBenev3=7 7. Strongly agree

AboveTrust2

I am willing to rely on the work-related judgments of those with more authority than me.

AboveTrust2=1 ○ 1. Strongly disagree

AboveTrust2=2 ○ 2. Disagree

AboveTrust2=3 ○ 3. Somewhat disagree

AboveTrust2=4 ○ 4. Neither agree nor disagree

AboveTrust2=5 ○ 5. Somewhat agree

AboveTrust2=6 ○ 6. Agree

AboveTrust2=7 ○ 7. Strongly agree

AboveTrust3

I can discuss how I honestly feel about work, **even negative feelings and frustration,** with those who have more authority than me.

AboveTrust3=1 ○ 1. Strongly disagree

AboveTrust3=2 ○ 2. Disagree

AboveTrust3=3 ○ 3. Somewhat disagree

AboveTrust3=4 ○ 4. Neither agree nor disagree

AboveTrust3=5 ○ 5. Somewhat agree

AboveTrust3=6 ○ 6. Agree

AboveTrust3=7 ○ 7. Strongly agree

--Page Break—

RiskTakingIntro

The following questions have to do with your approach to fire management. We are going to ask you about **innovative fire management strategies**. In this case, **innovative strategies are those that may have a greater chance of failure than tried-and-true strategies, but if they succeed, the rewards and benefits could be even greater.**

Please indicate the extent to which you agree or disagree with the following statements.

--Page Break—

RiskTakingIntro1

The following questions have to do with your approach to fire management. We are going to ask you about **innovative fire management strategies**. In this case, **innovative strategies are those that may have a greater chance of failure than tried-and-true strategies, but if they succeed, the rewards and benefits could be even greater.**

Please indicate the extent to which you agree or disagree with the following statements.

RiskSeeking1

When it comes to fire management, I prefer strategies perceived by many as risky.

RiskSeeking1=1 ◯ 1. Strongly disagree

RiskSeeking1=2 ◯ 2. Disagree

RiskSeeking1=3 ◯ 3. Somewhat disagree

RiskSeeking1=4 ◯ 4. Neither agree nor disagree

RiskSeeking1=5 ◯ 5. Somewhat agree

RiskSeeking1=6 ◯ 6. Agree

RiskSeeking1=7 ◯ 7. Strongly agree

RiskSeeking2

I am willing to try innovative fire management strategies.

- RiskSeeking2=1 ○ 1. Strongly disagree
- RiskSeeking2=2 ○ 2. Disagree
- RiskSeeking2=3 ○ 3. Somewhat disagree
- RiskSeeking2=4 ○ 4. Neither agree nor disagree
- RiskSeeking2=5 ○ 5. Somewhat agree
- RiskSeeking2=6 ○ 6. Agree
- RiskSeeking2=7 ○ 7. Strongly agree

RiskSeeking3

I try to explore innovative strategies for fire management.

- RiskSeeking3=1 ○ 1. Strongly disagree
- RiskSeeking3=2 ○ 2. Disagree
- RiskSeeking3=3 ○ 3. Somewhat disagree
- RiskSeeking3=4 ○ 4. Neither agree nor disagree
- RiskSeeking3=5 ○ 5. Somewhat agree
- RiskSeeking3=6 ○ 6. Agree
- RiskSeeking3=7 ○ 7. Strongly agree

RiskSeeking4

I am willing to try fire management strategies that I know are risky but have the potential to pay off.

RiskSeeking4=1 ○ 1. Strongly disagree

RiskSeeking4=2 ○ 2. Disagree

RiskSeeking4=3 ○ 3. Somewhat disagree

RiskSeeking4=4 ○ 4. Neither agree nor disagree

RiskSeeking4=5 ○ 5. Somewhat agree

RiskSeeking4=6 ○ 6. Agree

RiskSeeking4=7 ○ 7. Strongly agree

RiskAverse1

When it comes to fire management, I avoid strategies perceived by many as risky.

RiskAverse1=1 ○ 1. Strongly disagree

RiskAverse1=2 ○ 2. Disagree

RiskAverse1=3 ○ 3. Somewhat disagree

RiskAverse1=4 ○ 4. Neither agree nor disagree

RiskAverse1=5 ○ 5. Somewhat agree

RiskAverse1=6 ○ 6. Agree

RiskAverse1=7 ○ 7. Strongly agree

RiskAverse2

I feel most comfortable relying on tried-and-true fire management strategies.

- RiskAverse2=1 ○ 1. Strongly disagree
- RiskAverse2=2 ○ 2. Disagree
- RiskAverse2=3 ○ 3. Somewhat disagree
- RiskAverse2=4 ○ 4. Neither agree nor disagree
- RiskAverse2=5 ○ 5. Somewhat agree
- RiskAverse2=6 ○ 6. Agree
- RiskAverse2=7 ○ 7. Strongly agree

RiskAverse3

I prefer tried-and-true strategies over innovative fire management strategies.

- RiskAverse3=1 ○ 1. Strongly disagree
- RiskAverse3=2 ○ 2. Disagree
- RiskAverse3=3 ○ 3. Somewhat disagree
- RiskAverse3=4 ○ 4. Neither agree nor disagree
- RiskAverse3=5 ○ 5. Somewhat agree
- RiskAverse3=6 ○ 6. Agree
- RiskAverse3=7 ○ 7. Strongly agree

RiskAverse4

When in doubt, tried-and-true fire management strategies are the best option.

RiskAverse4=1 ○ 1. Strongly disagree

RiskAverse4=2 ○ 2. Disagree

RiskAverse4=3 ○ 3. Somewhat disagree

RiskAverse4=4 ○ 4. Neither agree nor disagree

RiskAverse4=5 ○ 5. Somewhat agree

RiskAverse4=6 ○ 6. Agree

RiskAverse4=7 ○ 7. Strongly agree

TriedandTrueOpen

Please briefly provide examples of what you consider tried-and-true fire management strategies in your position.

InnovativeOpen

Please briefly provide examples of what you consider innovative fire management strategies in your position.

--Page Break—

DemoIntro1

Thank you for your responses.

In this final section you will be asked to respond to several questions that will help us learn more about you and your job responsibilities. Please indicate your response by checking the appropriate box or filling in the appropriate response below each question.

FireJobTitle

What is the title of the position that you currently hold related to wildfire management? If you hold multiple titles, please select the title you serve as most often.

- FireJobTitle=1 ○ Division supervisor (DIVS)
- FireJobTitle=2 ○ Type 3 Incident Commander (ICT3)
- FireJobTitle=3 ○ Type 2 Incident Commander (ICT2)
- FireJobTitle=4 ○ Type 1 Incident Commander (ICT1)
- FireJobTitle=5 ○ Operations Section Chief
- FireJobTitle=6 ○ Technical specialist (FBAN, LTAN, GSAN, etc.)
- FireJobTitle=7 ○ FireJobTitle_7_other Other [ ]

YearsPosition

How many years have you been in the position you selected?
If you have been in this position less than a year, please answer "1".

[ ]

YearsFire

How many years in total have you been involved in wildfire management in any capacity?
If you have been in this position less than a year, please answer "1".

[ ]

AllFireJobs

Which of the following positions have you held where you were actively involved in wildfire management? Please select all that apply.

AllFireJobs_1 ☐ Firefighter (e.g., hotshot member, pilot, smokejumper, etc.)

AllFireJobs_2 ☐ Technical specialist (e.g., FBAN, LTAN, GSAN, etc.)

AllFireJobs_3 ☐ Division Supervisor

AllFireJobs_4 ☐ Operations Section Chief

AllFireJobs_5 ☐ Planning Section Chief

AllFireJobs_6 ☐ Incident Commander Type 3

AllFireJobs_7 ☐ Incident Commander Type 2

AllFireJobs_8 ☐ Incident Commander Type 1

AllFireJobs_9 ☐ Line officer

AllFireJobs_10 ☐ Duty officer

AllFireJobs_11 ☐ District Ranger or Deputy District Ranger

AllFireJobs_12 ☐ Forest Supervisor

AllFireJobs_13 ☐ AllFireJobs_13_other Other

EduAttain1

What is your highest level of education completed?

- EduAttain1=1 ○ Some high school
- EduAttain1=2 ○ High school
- EduAttain1=3 ○ Associate's degree
- EduAttain1=4 ○ Bachelor's degree
- EduAttain1=5 ○ Graduate degree (e.g., PhD, MS)
- EduAttain1=6 ○ EduAttain1_6_other Other

CollegeField1

If you hold a college degree or higher, what was the disciplinary focus of your highest degree?

- CollegeField1=1 ○ Biological sciences
- CollegeField1=2 ○ Geology or soil science
- CollegeField1=3 ○ Hydrology
- CollegeField1=4 ○ Forestry/silviculture
- CollegeField1=5 ○ Fire ecology/behavior
- CollegeField1=6 ○ Natural resource administration/management
- CollegeField1=7 ○ Geospatial Information Science (GIS)
- CollegeField1=8 ○ CollegeField1_8_other Other
- CollegeField1=9 ○ Not applicable

Gender1

What is your gender?

Gender1=1 ○ Female

Gender1=2 ○ Male

Gender1=3 ○ Other/prefer not to say

FollowUp

If you would be willing to answer follow-up questions and discuss your thoughts more with the research team please check this box.

FollowUp_1 ☐ The research team may contact me via email for additional follow-up questions

--Page Break—

Terminate1

Your responses have been recorded. If you have any questions please contact FireSurvey@osu.edu.
Thank you for taking our survey.

--End of Survey--

Appendix B: Chapter 3 Interview Guide

Chapter 3 Interview Guide: Fire Manager Trust Interviews

Block One: Groundwork Questions

1. Introductions, please describe your position:
    - How many years you've been in firefighting, in fire management, in this position?
        i. As needed: You said your position was [position]. What are the roles and responsibilities you have?
2. What does it mean to trust the people you work with on your job?
    - Does trust mean different things when you think about someone high in the chain of command like [possible examples: line officer, incident commander, operations section chief] versus someone lower in the chain of command like [possible examples: operations section chief, division supervisor, strike team leader]?
    - What does it mean to you to be trusted by other incident management personnel? Does it mean different things when you think about someone higher versus lower than you in the incident management change of command?

Randomly select. Start with either Block Two: Supervisors or Block Three: Subordinates.

Block Two: Supervisors

3. **[Supervisor Trust]** [To start, I'd like to focus on your relationships with your supervisors/I'd like to transition to talking about your supervisor] What are you looking for in a trustworthy supervisor?
    - What are some signs of an untrustworthy supervisor?
4. **[Supervisor Trust]** Please think of **someone you've worked under who you trust.** (Can also be in the past- trusted.)
    - Establish the relationship: How long have you known them? What is their role in the incident management team? Had you worked with them previously?
    - How did you come to trust them? Can you remember specific instances that contributed to whether or not you trusted them? **What makes them trustworthy?**
    - **<u>Always ask:</u>** Why do you trust [Name?]

- [Repeat as necessary, respondents can provide examples of people they distrusted]

5. **[Supervisor Felt Trust]** Now that we've talked about what you look for in a trustworthy supervisor, I'd like to ask about what you think **supervisors look for in a trustworthy [position]**.
    - What do you think supervisors are looking for in a trustworthy [respondent position]?
6. **[Supervisor Felt Trust]** Please think of **a supervisor who [trusts/trusted] you.** Is there anyone you worked with or have worked with who you thought trusted you a lot?
    - Establish the relationship: How long have you known them? What is their role in the incident management team? Had you worked with them previously?
    - How do they express that they trust you? Can you remember specific instances where they did something that made you feel trusted? Why do you think they decided to trust you? **Why do they think you're trustworthy?**
    - **Always ask:** If I asked [Name], "Why do you trust [Respondent]?" what do you think they would say?
    - [Repeat as necessary, respondents can provide examples of people who distrusted them]

Block Three: Subordinates

7. **[Subordinate Trust]** [To start, I'd like to focus on your relationships with your subordinates/I'd like to transition to talking about your subordinates] What are you looking for in a trustworthy direct report?
    - What are some signs of an untrustworthy direct report?
8. **[Subordinate Trust]** Please think of **someone you've supervised who you trust.** (Can also be in the past- trusted.)
    - Establish the relationship: How long have you known them? What is their role in the incident management team? Had you worked with them previously?
    - How did you come to trust them? Can you remember specific instances that contributed to whether or not you trusted them? **What makes them trustworthy?**
    - **Always ask:** Why do you trust [Name?]
    - [Repeat as necessary, respondents can provide examples of people they distrusted]
9. **[Subordinate Felt Trust]** Now that we've talked about what you look for in a trustworthy direct report, I'd like to ask about what you think **your direct reports look for in a trustworthy [position]**.
    - What do you think direct reports are looking for in a trustworthy [respondent position]?

10. **[Subordinate Felt Trust]** Please think of **a subordinate who [trusts/trusted] you.** Is there anyone you worked with or have worked with who you thought trusted you a lot?
    - Establish the relationship: How long have you known them? What is their role in the incident management team? Had you worked with them previously?
    - How do they express that they trust you? Can you remember specific instances where they did something that made you feel trusted? Why do you think they decided to trust you? **Why do they think you're trustworthy?**
    - **Always ask:** If I asked [Name], "Why do you trust [Respondent]?" what do you think they would say?
    - [Repeat as necessary, respondents can provide examples of people who distrusted them]

Block Four: Concluding Remarks

11. As we wrap up here, do you have any additional thoughts about anything we've talked about today?
12. **Always ask:** Is there anything you think I should have asked?

Appendix C: Chapter 4 Survey

Chapter 4 Survey: Trust Across Levels of Authority in Incident Management Teams Survey

Survey Logic:

- **Show Block:** Default Question Block
- **Show Block:** Preamble Questions
- **Randomizer:** Randomly present 1 of the following elements (evenly present elements)
    - **Show Block:** Condition 1: Supervisors First Intro
    - **Show Block:** Condition 2: Subordinates First Intro
- **Then Branch If** "Show Block: Condition 1: Supervisors First Intro" is displayed
    - **Randomizer:** Randomly present 2 of the following elements (evenly present elements)
        - **Show Block:** Trust Supervisors
        - **Show Block:** Felt Trust Supervisors
    - **Show Block:** Condition 1: Supervisors First Bridge
    - **Randomizer:** Randomly present 2 of the following elements
        - **Show Block:** Felt Trust Subordinate
        - **Show Block:** Felt Trust Subordinate
- **Then Branch If** "Show Block: Condition 2: Subordinates First Intro" is displayed
    - **Randomizer:** Randomly present 2 of the following elements
        - **Show Block:** Trust Subordinate
        - **Show Block:** Felt Trust Subordinate
    - **Show Block:** Condition 2: Subordinates First Bridge
    - **Randomizer:** Randomly present 2 of the following elements
        - **Show Block:** Trust Supervisors
        - **Show Block:** Felt Trust Supervisors
- **Show Block:** Team Learning and Team Performance
- **Show Block:** Demographics

Start of Block: Default Question Block

Q1.1 **The Ohio State University Consent to Participate in Research**
Study Title: Fire Manager Trust Study
Protocol Number: 2021E0419
Researcher: Dr. Robyn Wilson
Sponsor: NONE
This is a consent form for research participation. It contains important information about this study and what to expect if you decide to participate.

Your participation is voluntary.

Please consider the information carefully. Feel free to ask questions before making your decision whether or not to participate.

Purpose The purpose of this study is to assess your experience with supervisors and direct reports on incident management teams to better understand how IMT members develop trust in each other, share information, and achieve objectives.

Procedures/Tasks This study includes a survey. You will be asked a series of questions relating to your

experience working on an incident management team and your opinions of your supervisors and direct reports,. As well you will be asked questions about the overall team behavior and effectiveness. You will be asked some demographic information, but no identifying information. We estimate the entire study will take 15 minutes to complete.

Duration You may leave the study at any time. If you decide to stop participating in the study, there will be no penalty to you, and you will not lose any benefits to which you are otherwise entitled. Your decision will not affect your future relationship with The Ohio State University.

Confidentiality We will work to make sure that no one sees your online responses without approval. But, because we are using the Internet, there is a chance that someone could access your online responses without permission. In some cases, this information could be used to identify you. Also, there may be circumstances where this information must be released. For example, personal information regarding your participation in this study may be disclosed if required by state law. Also, your records may be reviewed by the following groups (as applicable to the research): · Office for Human Research Protections or other federal, state, or international regulatory agencies; · The Ohio State University Institutional Review Board or Office of Responsible Research Practices; · The sponsor, if any, or agency (including the Food and Drug Administration for FDA-regulated research) supporting the study.

Future Research Your de-identified information may be used or shared with other researchers without your additional informed consent.

Incentives: There are no incentives for participation in this study.

Participant Rights You may refuse to participate in this study without penalty. If you choose to participate in the study, you may discontinue participation at any time without penalty or loss of benefits. By agreeing to participate, you do not give up any personal legal rights you may have as a participant in this study.

This study has been determined Exempt from IRB review.

Contacts and Questions For questions, concerns, or complaints about the study you may contact rapp.172@osu.edu. For questions about your rights as a participant in this study or to discuss other study-related concerns or complaints with someone who is not part of the research team, you may contact the Office of Responsible Research Practices at 1-800-678-6251 or hsconcerns@osu.edu.

Providing consent I have read (or someone has read to me) this page and I am aware that I am being asked to participate in a research study. I have had the opportunity to ask questions and have had them answered to my satisfaction. I voluntarily agree to participate in this study. I am not giving up any legal rights by agreeing to participate.

To print or save a copy of this page, select the print button on your web browser.

Please click the button below to proceed and participate in this study. If you do not wish to participate, please close out your browser window.

End of Block: Default Question Block

Start of Block: Preamble Questions

Q2.1

In this survey we will be asking you about your experiences working with direct reports and supervisors on a previous fire.

Think back to **your most recent fire** that you served on that lasted longer than 48 hours and required at least a Type 3 Team **where you served as one of the following roles: Operations Section Chief or Branch Director (including air) Division Supervisor Task Force Leader or Strike Team Leader**

Please take a moment to recall your experience. Try to recall your supervisors and your direct reports, including your opinions of them and their opinions of you.

Q2.2 Please select which role you served as.

- ○ Operations Section Chief (including air) (1)
- ○ Branch Director (including air) (2)
- ○ Division supervisor (3)
- ○ Task Force Leader or Strike Team Leader (4)
- ○ I have never worked on a fire as any of these roles (5)

Page Break

Q2.3 Approximately how long ago was the fire?

- ○ 0 - 6 months ago (1)
- ○ 7 - 12 months ago (2)
- ○ 1 - 3 years ago (3)
- ○ More than 3 years ago (4)

Q27 What type of incident management team was ordered?

- ○ Type 1 (1)
- ○ Type 2 (2)
- ○ Type 3 (3)

Q2.4 Were you ordered as a single resource?

- Yes (1)
- No (2)

Q2.5
Which geographic area were you in for the fire?

- Pacific Northwest (1)
- Alaska (2)
- Northern California (3)
- Southern California (4)
- Great Basin (5)
- Southwest (6)
- Northern Rockies (7)
- Rocky Mountain (8)
- Southern (9)
- Eastern (10)

Q2.6 Please tell us a couple sentences about your experiences with other people in the operational chain of command on that fire. How many direct reports did you have? How often did you interact with them? How often did you interact with your supervisor?

_____

End of Block: Preamble Questions

Start of Block: Condition 1: Supervisors First Intro

Q3.1
Continuing to think about your experience on that fire, the following questions will assess your perceptions of both your immediate supervisor and direct reports and how they evaluated you. For example, if you served as a division supervisor, your immediate supervisor may have been a branch director or ops chief, and your direct reports may have been task force leaders or strike team leaders.

First we will be asking about your experience with your supervisor.

End of Block: Condition 1: Supervisors First Intro

Start of Block: Condition 2: Subordinates First Intro

Q4.1
Continuing to think about your experience on that fire, the following questions will assess your perceptions of both your immediate supervisor and direct reports and how they evaluated you. For example, if you served as a division supervisor, your immediate supervisor may have been a branch director or ops chief, and your direct reports may have been task force leaders or strike team leaders.

First we will be asking about your experience with direct reports.

End of Block: Condition 2: Subordinates First Intro

Start of Block: Trust Supervisors

Q5.1 Please indicate the extent to which you agree or disagree with the following statements with regards to **your supervisor.** For any statement if you **truly** don't have an opinion or don't know, please select "neither agree nor disagree".

	Strongly disagree (1)	Disagree (2)	Somewhat disagree (3)	Neither agree nor disagree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
My supervisor had well thought-out plans for how to achieve their goals. (1)	○	○	○	○	○	○	○
My supervisor produced results. (2)	○	○	○	○	○	○	○
My supervisor had excellent communication skills. (3)	○	○	○	○	○	○	○
My supervisor was honest when discussing plans and strategies. (4)	○	○	○	○	○	○	○
I believe my supervisor was in fire management for the right reasons. (5)	○	○	○	○	○	○	○
My supervisor owned bad outcomes instead of passing the buck. (6)	○	○	○	○	○	○	○
My supervisor modeled inclusive leadership for the rest of the team. (7)	○	○	○	○	○	○	○

My supervisor gave everyone autonomy to make decisions. (8)	○	○	○	○	○	○	○
My supervisor genuinely cared about the other members of the team. (9)	○	○	○	○	○	○	○
I was familiar with my supervisor before this fire. (10)	○	○	○	○	○	○	○
My supervisor had a similar "slide deck" of experiences as me. (11)	○	○	○	○	○	○	○
I shared common ground with my supervisor. (12)	○	○	○	○	○	○	○
My supervisor showed through their behaviors that they were trustworthy. (13)	○	○	○	○	○	○	○
I had confidence in my supervisor. (14)	○	○	○	○	○	○	○
My supervisor was trustworthy. (15)	○	○	○	○	○	○	○

End of Block: Trust Supervisors

Start of Block: Felt Trust Supervisor

Q6.1 The following statements pertain to **your supervisor's opinion of you**. To the best of your knowledge, please indicate the extent to which you agree or disagree with the following statements about **what your supervisor thought about you.** For any statement if you **truly** don't have an opinion or don't know, please select "neither agree nor disagree".

	Strongly disagree (1)	Disagree (2)	Somewhat disagree (3)	Neither agree nor disagree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
My supervisor thought I had well thought-out plans for how to achieve my goals. (1)	○	○	○	○	○	○	○
My supervisor thought I produced results. (2)	○	○	○	○	○	○	○
My supervisor thought I had excellent communication skills. (3)	○	○	○	○	○	○	○
My supervisor thought I was honest when discussing plans and strategies. (4)	○	○	○	○	○	○	○
I believe my supervisor thought I was in fire management for the right reasons. (5)	○	○	○	○	○	○	○
My supervisor thought I owned bad outcomes instead of passing the buck. (6)	○	○	○	○	○	○	○

My supervisor thought I modeled inclusive leadership for the rest of the team. (7)	○	○	○	○	○	○	○
My supervisor thought I gave my subordinates autonomy to make decisions. (8)	○	○	○	○	○	○	○
My supervisor thought I genuinely cared about the other members of the team. (9)	○	○	○	○	○	○	○
My supervisor was familiar with me before this fire. (10)	○	○	○	○	○	○	○
My supervisor thought I had a similar "slide deck" of experiences as them. (11)	○	○	○	○	○	○	○
My supervisor thought I shared common ground with them. (12)	○	○	○	○	○	○	○
My supervisor showed through their behavior that they trusted me. (13)	○	○	○	○	○	○	○

My supervisor clearly communicated they had confidence in me. (14)	○	○	○	○	○	○	○
My supervisor believed I was trustworthy. (15)	○	○	○	○	○	○	○

End of Block: Felt Trust Supervisor

Start of Block: Condition 1: Supervisors First Bridge

Q7.1 In the next section, please continue to think about your experience on the same fire. We will now be asking you questions about your **direct reports.**

End of Block: Condition 1: Supervisors First Bridge

Start of Block: Felt Trust Subordinate

Q8.1 The following statements pertain to **your direct reports' opinion of you**. To the best of your knowledge, please indicate the extent to which you agree or disagree with the following statements about **what your direct reports thought about you.** For any statement if you **truly** don't have an opinion or don't know, please select "neither agree nor disagree".

	Strongly disagree (1)	Disagree (2)	Somewhat disagree (3)	Neither agree nor disagree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
My direct reports thought I had well thought-out plans for how to achieve my goals. (1)	○	○	○	○	○	○	○
My direct reports thought I produced results. (2)	○	○	○	○	○	○	○
My direct reports thought I had excellent communication skills. (3)	○	○	○	○	○	○	○
My direct reports thought I was honest when discussing plans and strategies. (4)	○	○	○	○	○	○	○
My direct reports thought I was in this field of work for the right reasons. (5)	○	○	○	○	○	○	○
My direct reports thought I owned bad outcomes instead of passing the buck. (6)	○	○	○	○	○	○	○

My direct reports thought I modeled inclusive leadership for the rest of the team. (7)	○	○	○	○	○	○	○
My direct reports thought I gave them autonomy to make decisions. (8)	○	○	○	○	○	○	○
My direct reports thought I genuinely cared about the other members of the team. (9)	○	○	○	○	○	○	○
My direct reports were familiar with me before this fire. (10)	○	○	○	○	○	○	○
My direct reports thought I had a similar "slide deck" of experiences as them. (11)	○	○	○	○	○	○	○
My direct reports thought I shared common ground with them. (12)	○	○	○	○	○	○	○

My direct reports showed through their behavior that they trusted me. (13)	○	○	○	○	○	○	○
My direct reports clearly communicated they had confidence in me. (14)	○	○	○	○	○	○	○
My direct reports believed I was trustworthy. (15)	○	○	○	○	○	○	○

End of Block: Felt Trust Subordinate

Start of Block: Trust Subordinate

Q9.1 Please indicate the extent to which you agree or disagree with the following statements with regards to **your direct reports.** For any statement if you **truly** don't have an opinion or don't know, please select "neither agree nor disagree".

	Strongly disagree (1)	Disagree (2)	Somewhat disagree (3)	Neither agree nor disagree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
My direct reports had well thought-out plans for how to achieve their goals. (1)	○	○	○	○	○	○	○
My direct reports produced results. (2)	○	○	○	○	○	○	○
My direct reports had excellent communication skills. (3)	○	○	○	○	○	○	○
My direct reports were honest when discussing plans and strategies. (4)	○	○	○	○	○	○	○
I believe my direct reports were in fire management for the right reasons. (5)	○	○	○	○	○	○	○
My direct reports owned bad outcomes instead of passing the buck. (6)	○	○	○	○	○	○	○

My direct reports modeled inclusive leadership for their own subordinates. (7)	○	○	○	○	○	○	○
My direct reports gave their own subordinates autonomy to make decisions. (8)	○	○	○	○	○	○	○
My direct reports genuinely cared about the well-being of other members of the team. (9)	○	○	○	○	○	○	○
I was familiar with my direct reports before this fire. (10)	○	○	○	○	○	○	○
My direct reports had a similar "slide deck" of experiences as me. (11)	○	○	○	○	○	○	○
I shared common ground with my direct reports. (12)	○	○	○	○	○	○	○
My direct reports showed through their behaviors that they were trustworthy. (13)	○	○	○	○	○	○	○

I had confidence in my direct reports. (14)	○	○	○	○	○	○	○
My direct reports were trustworthy. (15)	○	○	○	○	○	○	○

End of Block: Trust Subordinate

Start of Block: Condition 2: Subordinates First Bridge

Q10.1 In the next section, please continue to think about your experience on the same fire. We will now be asking you questions about your **supervisor.**

End of Block: Condition 2: Subordinates First Bridge

Start of Block: Team Learning and Team Performance

Q11.1 In the following section we are interested in your opinion of the incident management team more broadly, **including but not limited to your direct reports and supervisors.**

Q11.2 Please indicate the extent to which you agree or disagree with the following statements.

	Strongly disagree (1)	Disagree (2)	Somewhat disagree (3)	Neither agree nor disagree (4)	Somewhat agree (5)	Agree (6)	Strongly Agree (7)
The team relied on outdated information or ideas. (1)	○	○	○	○	○	○	○
The team regularly took time to figure out ways to improve its performance. (2)	○	○	○	○	○	○	○
Team members asked for help from others in the team when something came up that they didn't know how to handle. (3)	○	○	○	○	○	○	○
The team actively reviewed its own progress and performance. (4)	○	○	○	○	○	○	○
The team did its work without stopping to consider all the information team members have. (5)	○	○	○	○	○	○	○

The team ignored feedback from each other. (6)	○	○	○	○	○	○	○
I believe we managed the fire successfully. (7)	○	○	○	○	○	○	○
The team functioned effectively and efficiently. (8)	○	○	○	○	○	○	○
At the end of the day, I believe we did a good job. (9)	○	○	○	○	○	○	○
We successfully achieved our team-level goals and objectives. (10)	○	○	○	○	○	○	○

End of Block: Team Learning and Team Performance

Start of Block: Demographics

Q12.1 Thank you for your participation. In this final section, you will be asked to respond to several questions that will help us learn more about you and your job responsibilities. Please indicate your response by checking the appropriate box or filling in the appropriate response below each question.

Q12.2 What is your **highest qualification** on incident management teams?

- ○ Type 3 Incident Commander (1)
- ○ Type 2 Incident Commander (2)
- ○ Type 1 Incident Commander (3)
- ○ Type 1 or 2 Operations Section Chief (4)
- ○ Operations Branch Director (5)
- ○ Division Supervisor (6)
- ○ Other (7) _____

Q12.3 What position do you serve as **most frequently** on incident management teams?

- ○ Type 3 Incident Commander (1)
- ○ Type 2 Incident Commander (2)
- ○ Type 1 Incident Commander (3)
- ○ Type 1 or 2 Operations Section Chief (4)
- ○ Operations Branch Director (5)
- ○ Division Supervisor (6)
- ○ Other (7) _____

Q12.4 How many years have you been in the position you serve as most frequently?

_____

Q12.5 How many years have you worked in fire management, including suppression and prescribed fire?

_____

Q28 During an average year, on how many wildfire events do you serve in the operations section? Exclude prescribed burns but include escaped burns. If you serve on less than one wildfire a year (e.g., one every five years) please indicate how many years go by on average between fires.

_____

Q12.6 Which of the following agencies do you currently work for?

- ○ US Bureau of Land Management (1)
- ○ US Forest Service (2)
- ○ US National Park Service (3)
- ○ US Fish and Wildlife Service (4)
- ○ State-level fire, forestry, park, or natural resource department (5)
- ○ Other (6) _____

Q12.7
Which geographic area are you stationed at for your non-IMT job?

- ○ Pacific Northwest (1)
- ○ Alaska (2)
- ○ Northern California (3)
- ○ Southern California (4)
- ○ Great Basin (5)
- ○ Southwest (6)
- ○ Northern Rockies (7)
- ○ Rocky Mountain (8)
- ○ Southern (9)
- ○ Eastern (10)

Q12.8 What is your highest level of education completed?

- ○ Some high school (1)
- ○ High school (2)
- ○ Associate's degree (3)
- ○ Bachelor's degree (4)
- ○ Graduate degree (e.g., PhD, MS) (5)
- ○ Other (6) _____

Q12.9 What is your gender?

- Male (1)
- Female (2)
- Other/Prefer not to say (3)

End of Block: Demographics
