

Risk Management: Core Principles and Practices, and their Relevance to Wildland Fire

Matthew P. Thompson, Donald G. MacGregor, and David E. Calkin



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Abstract

The Forest Service, U.S. Department of Agriculture faces a future of increasing complexity and risk, pressing financial issues, and the inescapable possibility of loss of human life. These issues are perhaps most acute for wildland fire management, the highest risk activity in which the Forest Service engages. Risk management (RM) has long been put forth as an appropriate approach for addressing fire, and agency-wide adoption of RM principles and practices will be critical to bring about necessary change and improve future decisions. To facilitate more comprehensive adoption of formal RM frameworks, we designed this report as an introduction to RM. We repackaged and repurposed information from the extant RM literature to help readers develop a sound, science-based understanding of RM concepts. A primary intent of the report is to bring coherence and consistency to a topic that the Forest Service and the fire community have been discussing for years. We outline what adoption of RM would look like in practice, and recommend next steps as the Forest Service continues on its RM journey. Ultimately, we hope fostering an improved understanding of RM will lead to higher probabilities of achieving desired outcomes and conditions.

Keywords: risk, uncertainty, assessment, planning, accountability, decisions

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Foreword

Fire and risk are inexorably linked. This unique General Technical Report brings significant and important clarity to words we frequently invoke as we deal with wildland fire risk management. This is a report that wildland fire and aviation management professionals, natural resource management leaders, and those affected by wildland fire should read. We should then think, discuss, and act.

This publication comes at a pivotal time for wildland fire management in the United States. This report specifically explores and explains the concepts of risk management for wildland fire at the organizational scale. As the authors note, the practice of risk management as a specific discipline has been widely and successfully used in a variety of other organizations and settings, and has proven worthy of investment in time, capital, and energy.

Risk management concerns the impact of uncertainty on objectives. Objectives are a prime consideration in our wildland fire world. The most elemental of those critical objectives is to treasure life. The concepts of risk management, applied at the personal and organizational scale, will help us protect life while we conserve our wildlands. The practice of risk management, as intended by risk professionals, will help provide clarity, focus, and alignment at the tactical and landscape scale.

Those of us who live in, work in, or enjoy the wildlands of America understand the significant role of fire in our landscapes. For us in the wildland fire and aviation management profession, dealing with fire is “risky business”; it is so at the individual level and at the organizational scale. Risk management is a much broader discipline than wildland fire and natural resource management in a single agency—but wildland fire is an opportune place to examine how risk management concepts and practices will improve our work of conserving lives, protecting communities, and sustaining landscapes. Although this report focuses discussion on issues within the U.S. Forest Service, these concepts have broader application.

The more important the individual and organizational role in leading, the more critical it is to think. This paper, with its call for more rigorous application of risk management principles at much broader scales, is an important component of helping us “think.”

The need to think is more important than ever. As we look to the future, we see a more complex world, interwoven with a variety of the known and unknown, each of which generally will combine to produce additional wildland fire and aviation management risk. Increased wildland fire and aviation management risk has impacted the U.S. Forest Service. Increased risk in the future will most certainly impact a broader segment of the public, responders, and the land.

This report proposes accomplishing our work more efficiently and effectively, while lowering risk to the public, responders, and the land. It challenges us to bring disparate elements together in the context of coherence and analysis within a proven way of thinking. Effectiveness in wildland fire management must put into practice elements of ecology, social science, economics, behavioral science, policy, and other disciplines. We apply those disciplines at a variety of scales and in a variety of situations. This paper urges us to adopt the proven concepts of risk management on a broader scale and in a more determined manner than in the past. It describes a framework for pulling elements

together and using them in the context of the decisions we must make. After all, given the dynamic nature of wildland fire, there is no “stasis” or “no action” option.

Disconnected and discordant systems will not be sustained. Simply applying pieces of the discipline of risk management locally, personally, intuitively, tactically, and experientially will not provide the foundation we require to successfully navigate our uncertain future. The discussion of risk management in this report is not an indictment of our past; it is a call to “do better. This report is a call to act.

Richard Pascale said that we are all much more likely to act our way into a different way of thinking than to think our way into a different way of acting. This paper urges us to “act differently.”

Please read, study, and ponder this report. Implementing risk management in the U.S. Forest Service and in our interagency wildland fire system as these authors have challenged us to do will lead us to a better future. We need to act our way into a different way of thinking.

Tom Harbour

Retired, National Director, Fire and Aviation Management

U.S. Forest Service

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Executive Summary

So even with all of the improvements we have made over more than a century of wildland firefighting, the broader wildland fire community continues to lose people at an appalling rate...It's our job, as leaders and managers, to ensure that firefighters are exposed to hazards only when the gain outweighs the risk.

Tom Tidwell, Chief of the U.S. Forest Service, April 2015¹

The Forest Service, U.S. Department of Agriculture (USFS) is at a crossroads—it faces crucial decisions regarding the future of its wildland fire management program. This future entails more complexity, risk, and scrutiny, and the inescapable possibility of loss of human life. Managing fire is the Forest Service's highest risk activity. The agency must be able to assure that fire responders are in the right place at the right time with the right strategy.

Undesirable fire management outcomes also include destruction of property, deterioration of ecological conditions, and a compromised ability to achieve core missions due to the growing budgetary impacts of wildfire suppression. It is becoming clear that business-as-usual leads to an unsustainable trajectory.

Failure to act in the face of these circumstances is likely to have major consequences to the Forest Service and to society. As the world's largest wildfire management organization with a dedicated research branch, the Forest Service is well positioned to address this situation. To achieve better outcomes in the future, the Forest Service must lead by example and design and implement change to frameworks for resource management and decisionmaking. Simply increasing the scale of response will not lead to more desirable outcomes.

In this report we contend that Forest Service-wide adoption of risk management (RM) principles and practices will be critical to effect change and improve decisions, ultimately leading to higher probabilities of achieving desired outcomes and conditions. However, this report primarily focuses on the wildland fire management component of the agency because it presents a high health and safety risk, significant budgetary implications, and frequent opportunities for RM practice. We recognize that the wildland fire community has been working at RM for a long time, and we acknowledge many successes along the way. What we argue for here is a more disciplined, coherent, and comprehensive approach—in other words, an enterprise RM approach. Throughout this document we describe opportunities for the Forest Service to more fully embrace an RM framework for decisionmaking. We are not arguing for policy changes; rather our focus on RM is deeply rooted in existing policy and planning documents (e.g., the 1995 Federal Wildland Fire Management Policy, the 2009 Guidance for Implementation of Federal Wildland Fire Management Policy, and the Forest Service 2015–2020 Strategic Plan). We believe that more fully incorporating the principles we present in this document will help the Forest Service to more effectively and efficiently implement existing policy.

¹ Chief Tidwell's comments at the 13th Fire Safety Summit and 4th Human Dimensions in Wildland Fire Conference held in Boise, Idaho, in April 2015; see <http://wildfiremagazine.org/article/the-human-dimension-of-safety-in-the-wildland-fire-environment/>.

RM requires dedicated, systematic assessment and management of risks as well as opportunities. This further requires a focus on how to best achieve broad organizational objectives, keeping in mind that some features of the organization (e.g., segmentation and “silos”) may themselves constitute risk factors. The value in enterprise-level RM resides (in large part) in its recognition of the systemic nature of risk.

RM is a longstanding, mature discipline that has helped organizations across sectors and domains improve their business practices and achieve objectives. Central tenets of RM include integrating risk principles into all organizational processes and decisions, embracing an uncertain world and developing a familiarity with probability, committing to generating and using the best available information, developing systems of accountability to monitor performance, and using that information to facilitate continual improvement. RM organizations are proactive, invest time and resources in upstream assessment and planning, and as a result are less susceptible to the vagaries of uncertain, time-pressured decision environments.

Our objectives for writing this report are to:

- Describe the arguments for the Forest Service to more formally adopt an RM framework
- Help readers develop a sound, science-based understanding of RM concepts, principles, and practices
- Outline what adoption of RM would look like in practice, and offer recommendations for next steps as the Forest Service continues on its RM journey
- Engender Forest Service ownership in and commitment to the level of investment in assessment, planning, and accountability that true enterprise-wide RM requires
- Ultimately help improve how, why, and with what information decisions are made, so that we can have improved outcomes and transparency

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Introduction

Sound risk management is a foundation for all fire management activities. Risks and uncertainties relating to fire management activities must be understood, analyzed, communicated, and managed as they relate to the cost of either doing or not doing an activity.

1995 Federal Wildland Fire Management: Policy and Program Review¹

Risk—essentially a measure of the probability and consequence of uncertain events—is and always has been an inevitable element of forest and grassland management. Forest Service managers face risks created by natural phenomena, as well as risks that are introduced when actions are taken. Fire management is a classic example: Fires present risks to things that society values, and fire responders take on risks when they manage fires. This is not an abstract tradeoff; fire responders die almost every year. It is necessary to ensure that high-impact management decisions are well informed and appropriately balance these types of risk-risk tradeoffs.

A focus on RM has long been a cornerstone of the wildland fire management community, from the 1995 Federal Wildland Fire Management Policy to more recent efforts like the National Cohesive Wildland Fire Management Strategy and the Forest Service's 2015–2020 Strategic Plan. Risk management (RM) principles have been incorporated into operational aviation procedures, project development and forest planning efforts, incident decision support, and budgetary allocation processes, among many examples. As these efforts mature, land and fire managers are increasingly asked to demonstrate how they have adopted RM principles, to analyze and communicate risks, and to transparently make risk-informed decisions.

As the public's expectations of natural resource managers have risen, so too has the complexity of the wildland fire environment, in dramatic ways. Managers are witnessing extreme fire behavior driven by increased fuel loads, long-duration drought, and more severe fire weather due to global climate change. Coupled with stressed ecosystems, increasing demand for water, and expanded development of the wildland-urban interface, these changes are driving increased losses and elevated response costs.

Yet throughout this period of increasing complexity, the organizational structure and approach to managing most wildfires has changed little. Despite a fundamental change in the fire environment, the Forest Service's response has been essentially to increase the scale and scope of suppression effort. This approach of increasing the scale of response has in part led to current concerns: an increasing risk trajectory, loss of more

¹ http://www.forestsandrangelands.gov/strategy/documents/foundational/1995_fed_wildland_fire_policy_program_report.pdf

fire responder lives, lack of accountability across most levels of the fire management organization, and serious questions about the sustainability of public land management agencies whose budget and activities are dominated by fire management response. It is becoming more and more apparent that business-as-usual is unsustainable and will lead to inexorably increasing costs and losses. A paradigm shift is necessary (for more information see the Annotated Bibliography, especially Calkin et al. [2015]) and Olsen et al. [2015]).

Relying on good people to make sound decisions has been and will remain central to the business model. But at the same time it is necessary to recognize that the current decision environment is far more complex and uncertain. Equally important is recognition that the accumulated impact of past decisions has contributed to the current situation with its myriad challenges, and that today's decisions must be evaluated in light of tomorrow's potential unanticipated or undesirable consequences. We must set the stage for managers at all levels to be able to systematically identify knowns and unknowns, confidently address uncertainties, and make high-quality, risk-informed decisions.

We are at a critical moment in the history of the Forest Service. Urgent action is needed in order to ensure that the Forest Service does not become further hindered by the continually increasing percentage of our budget that is dedicated to wildfire suppression activities.

Tom Tidwell, October 2015²

Consider the management of national forests and grasslands as a form of investment where the goal is to “grow the value” of the Forest Service's land, resources, and services to society. This investment has uncertain returns given the growing financial, social, and ecological risks the Forest Service faces. How well does the Forest Service understand those risks? How well is the Forest Service prepared to manage those risks? Finding solutions to better manage impacts of wildfire suppression on lives, property, and the agency budget is not a simple task, nor is demonstrating that proposed solutions would be efficient investments and a wise use of taxpayer dollars.

We believe that the pathway forward is to rely on advances in the risk and decision sciences that provide frameworks and concepts that can improve how the Forest Service deals with complex and uncertain problems. This body of science is well established and has been applied to a range of problems, including military applications (e.g., aircraft equipment failure), clean air and water (e.g., risk to public health from exposure to particulate matter in air and contaminants in water), food and product safety (e.g., public exposure to food contaminants and risks to motor vehicle drivers), and natural hazards (e.g., seismic and volcanic risks). However, the adoption and application of RM principles and practices can be challenging and even uncomfortable. At the same time, RM can improve returns on investments that the Forest Service makes, ensure safe and effective decisionmaking, and demonstrate organizational accountability. We would argue RM is the best bet for the Forest Service to protect lives and remain a sustainable organization that empowers its employees to promote the health and resilience of the Nation's public lands.

² Testimony before the House Committee on Agriculture, Subcommittee on Conservation and Forestry Subcommittee.

Because of the preeminent focus on protecting lives, and because of the urgent nature of its application, in this report we focus largely on wildland fire management. We see other areas where RM would have value (e.g., climate change adaptation and mitigation, invasive species management), and to fully integrate all the pieces will most likely require the cross-cutting vision, system-wide perspective, and commitment that come with enterprise RM at the agency level. We believe that starting with fire management is sensible for a number of reasons. First, as we stated earlier, it presents the single greatest human health and safety risk the Forest Service faces. Second, fire management budgetary impacts challenge the ability to attain other core missions and present threats to the fiscal health of the Forest Service. Third, fire provides the Forest Service a fair amount of opportunity to hone and improve its RM capabilities; in some frequent-fire areas, Forest Service managers may experience at least one significant fire event every season.

In this report, we will describe principles of formalized RM, identify and illustrate the practices of RM as applied to fire management, and chart a path for the Forest Service to become a true RM organization. Note that the RM principles we will articulate can operate at all organizational levels. Note also that while topics like deliberation, communication, situational awareness, and tactical fire responder decisionmaking are critically important, the type of RM we describe is much bigger—it involves analytical rigor, is information-intensive, and requires a system of accountability across all levels of the organization. RM requires us to openly ask hard questions of ourselves and of the organization.

- Will the Forest Service recognize that fire management entails exposing fire responders to hazardous conditions, and that these conditions in rare cases may lead to serious injury or fatality? Will the Forest Service provide the appropriate guidance to recognize when such exposure is warranted, and ensure fire responders are informed and aware of the risks they are accepting in pursuit of fire management objectives?
- Will the Forest Service accept an inherently uncertain world where good decisions can lead to bad outcomes, and will the Forest Service openly support managers who experience bad outcomes despite good decisions?
- Will the Forest Service establish risk-informed fire management objectives that provide clear guidance to managers, ensure accountability, and maintain public trust?
- Will the Forest Service develop a system where fire managers are accountable for decisions, and will the Forest Service transparently critique and, where necessary, modify its decision processes?
- Will the Forest Service sufficiently invest in becoming an RM organization, including:

What Does Risk Management Enable Organizations To Do?

- Increase the likelihood of achieving objectives
- Proactively identify and treat risks
- Improve governance
- Improve stakeholder confidence and trust
- Establish a reliable basis for decision-making and planning
- Effectively allocate and use resources
- Improve operational effectiveness, efficiency, and safety
- Enhance health and safety performance and environmental protection
- Improve loss prevention and incident management
- Minimize losses and maximize benefits
- Improve organizational learning
- Improve organizational resilience

- ◇ Educating and building capacity for a risk-informed workforce capable of assessing and managing risk?
- ◇ Conducting monitoring and research to generate the knowledge base necessary to improve risk-based decisions?
- ◇ Engaging with partners in shared management of risks?
- Will the Forest Service make the transition from treating partially knowable and predictable events as unpredictable crises, and invest in sufficient levels of planning that relate to the specific landscape and include the specific individuals who will be responding to the fire?
- Will the Forest Service be able to achieve its core missions if fire management continues to consume an ever-growing share of time, resources, and effort?

We maintain that addressing these, and other, hard questions will be an important step on the Forest Service’s ongoing RM journey. It will also be important to cultivate an enterprise-level understanding of and approach to RM. As a means to that end, we conclude this report by offering a series of recommendations to facilitate the Forest Service’s transition to a true RM organization. In particular we focus on three areas—leadership, education and capacity, and assessment and planning—while recognizing that attention to other areas will be necessary as well. Committing energy and focus to RM may entail a realignment of priorities and changes in how the agency invests its time and resources. Although we do not purport to have the answers to all questions or to offer the solutions to all problems, we do argue that RM is a sound, science-based way to help the agency navigate toward its desired horizon.

Risk Management Concepts and Principles

In this section, we will describe what RM can be when it generates and sustains the greatest value for an organization. We will begin by dispelling some possible misconceptions about what RM is and is not, at least as we see it. RM is a broad umbrella that considers a range of decisions from the high-impact to the mundane, and that spans organizational and individual actions before, during, and after decisions; RM is not a process that begins only when a decision needs to be made or after a decision has been made. RM is sensitive to human and cultural factors and is responsive to change; RM is not a one-size-fits-all approach. RM is perhaps best described as a journey that facilitates continual improvement of the organization; RM is not an endpoint to be reached as a goal in and of itself.

RM goes to the heart of how an organization grapples with the problems of uncertainty and complexity. It is about identifying whether and what types of decisions need to be made, when they are to be made,

A Working Definition of Risk Management

RM is a set of coordinated processes and activities that identify, monitor, assess, prioritize, and control risks that an organization faces.

how they should be made, and who should be involved. When a decision needs to be made, RM is essentially decisionmaking under uncertainty. Sometimes a decision is required; more often it is not. A great deal of RM is observing, orienting, analyzing trends, and other activities that lead managers to recognize the need for changes in how “business” is done. RM is “corporate,” is focused on the long-term interests of the organization, and tries to shed “silos” and “stove pipes.”

RM entails adopting, adapting, and applying best practices, many of which have evolved out of real environmental management problems for which documented justifications are necessary. In nearly all cases, the best practice is more than thinking hard; managers are expected to have analyses that can show how and why they reached a particular decision (or realized a decision was not necessary). These analyses are expected to be structured, systematic, timely, and based on the best available information and best available science. RM is therefore iterative, incorporates learning and feedbacks, is intentional about processes and practices, explicitly addresses uncertainty, and focuses on decision quality and corresponding outcomes. In fact, RM is by necessity iterative, in order to be responsive to changing conditions and to ensure decisions are based on up-to-date and accurate information.

Time Is a Resource

Time pressure is the enemy of good decisionmaking. You can buy yourself more time through careful analysis and planning.

RM involves assessment and planning well in advance of decisions that organizations or individuals are likely to face down the road. Some decisions have time requirements that can be met only by getting well ahead of a problem; RM can provide the foresight to realize that temporal horizon. Getting ahead of the problem through “upstream” planning helps buy time, reduces uncertainty, and expands the decision space. Upstream planning is particularly critical for time-pressured decisions.

Embracing these changes across all levels of an organization can provide broader perspective and foresight. RM can help improve understanding of how risks cascade across levels of an organization, and how problem context, available information, and analytical needs vary across these levels. In the best case, RM can even help identify unseen or underestimated risks. If done well, it will result in an organization that can better respond to critiques by an oversight agency, can better justify how and why decisions were made, can better describe how assessment and planning supported those decisions, and most importantly, can better demonstrate how outcomes are improving (see Box 1).

Risk Management—The Interface Between Science and Values

We are not saying that RM is a technical approach to solving a heretofore “social” or values problem. The various elements of RM (e.g., risk assessment and analysis) are value laden and a matter of judgment through and through. But the processes are structured and make more clear, for example, the elements that various parties agree upon and those that they do not. Likewise, RM can set criteria for inclusion (e.g., Who is exposed? How much? What opportunities for mitigation?) that can serve to make inclusivity directly relevant to the management problem at hand and not simply a platitudinous way to get everyone into the conversation. The terms “structure” and “rigor” should appear in the way we talk about the importance of values, such as engagement, inclusion, and transparency.

Box 1: Why Should Land and Fire Managers Care about Risk Management?

It is the right thing to do

- Risk management, done properly, will increase the probability of sustaining life, minimize catastrophic failure, and help achieve organizational objectives

“Live long and prosper”—the Dr. Spock argument

- Risk management is, quite simply, the most logical approach to address wildland fire management. Risk management provides a rich toolkit to face uncertainties head on, and to develop effective and efficient approaches to minimize losses and maximize benefits.

It is the “science-based” thing to do

- Risk science has been maturing for decades and provides a solid foundation to support land and fire management decisions. Wildland fire risk management is premised on the blending of multiple scientific disciplines, including fire ecology, silviculture, wildlife biology, forest engineering, and economics.

Everyone else is doing it

- Managers and decisionmakers across a range of sectors—not just finance and insurance—adopt risk management principles. The U.S. Environmental Protection Agency has long been a leader in developing and promoting frameworks to assess risks to human health and safety. Other Federal agencies and entities, such as the Federal Emergency Management Agency, the Centers for Disease Control and Prevention, the Army Corps of Engineers, and the Food and Drug Administration, adopt risk management principles.

It is the professional thing to do

- Risk management is the logical thing to do, it is the science-based thing to do, and our Federal peers already embrace it. The professional thing to do is continue strengthening risk management within the Forest Service.

What Are the Main Principles of Risk Management?

- Creates and protects value
- Is an integral part of all organizational processes
- Is part of decisionmaking
- Explicitly addresses uncertainty
- Is systematic, structured, and timely
- Is based on the best available information
- Is tailored to context
- Accounts for human and cultural factors
- Is transparent and inclusive
- Is dynamic, iterative, and responsive to change
- Facilitates continual improvement

How Is Risk Management Different from “Business as Usual”?

- Informal → formal
- Implicit → explicit
- Intuitive → analytical
- Reactive → proactive
- Tactical → strategic
- Local interests → organizational interests
- Short-term perspective → long-term perspective

Achieving Organizational Accountability Through Risk Management

Accountability is important because it is concerned with those aspects of an organization's behavior that impact its need to maintain *sustainability* and to support organizational learning. Accountability clarifies the connection between the decisions an organization makes and the outcomes that are realized. Without accountability, there is no basis for tracking or correcting organizational behavior, even when corrections would be in the organization's best interests. Accountability is a principle-based structure for guiding organizations, based on the formalization of practices by which an organization should abide to achieve a strategic response to sustainability. Principles of accountability provide the basis for an organization to manage those things that are most important to its sustainability.

Although accountability is an organizational value that is part of a general attitude that members of the organization bring to their job, *principles of accountability* attach to the organization certain responsibilities with respect to both itself and those outside the organization who are impacted by it. Furthermore, they are *explicit*—with a definition that can be made operational as part of management practice—and are broadly applicable. They have validity in any context where an organization desires to operate in its best long-term interests and with a clear recognition of the value of a supportive operating environment.

Principle 1: Sustainability

The concept of sustainability is central to many discussions about the future of economic systems that rely on natural resources, and especially in light of climate change. But sustainability goes beyond the “hard goods” that are required for an entity to function. It also requires social resources in the form of relationships with individuals, groups, governments, and cultures—in short (and in the broadest terms), stakeholders. The premise of accountability is that an organization values sustainability and preserves sustainability through recognition of the systemic relationship it holds with those outside of itself.

Principle 2: Inclusivity

For an organization to be fair and accountable to its stakeholders, it must be *inclusive* with respect to those it impacts and those who have an impact upon it. To be inclusive means to participate with stakeholders in developing strategies and solutions that are an accountable and strategic response to sustainability. Inclusivity goes beyond stakeholder engagement. It does not mean that all stakeholders' needs and requests will be accommodated in an attempt to ensure positive stakeholder relations. To achieve inclusivity requires an organizational commitment to a process of engagement and participation that requires a balanced involvement and that is based on a comprehensive understanding of who its stakeholders are, the human and cultural factors that drive their needs and concerns, and the ways in which they engage.

Principle 3: Materiality

To make the best decisions in the interests of sustainability, an organization and its stakeholders need to know the issues that are material to the performance of the organization. This knowledge drives what information is needed, when information is needed, and what timeframes govern decisions. Long-, medium-, and short-term trends are introduced and evaluated for both the organization and its stakeholders. The organization maintains alignment between its strategic decisions and the drivers of sustainability.

Principle 4: Responsiveness

Sometimes the focus of sustainability can appear to be only on an organization. But stakeholders also have sustainability issues, and these issues can affect an organization. Responsiveness is an organization's response to stakeholder issues and represents how an organization is accountable to stakeholders. Responsiveness requires the participation of stakeholders in developing responses. A responsive organization responds to its material issues as well as to those of its stakeholders in a timely, balanced, and comprehensive manner.

Accountability principles and risk management principles operate together to support making effective sustainability decisions. In many, if not all, organizations the achievement of objectives requires addressing risk-related issues. Sometimes these issues involve the investment of capital assets to provide a long-term return, such as when the Forest Service invests funds in hazardous fuels management. Sometimes they involve exposing valued resources to the inherent risks of a hazardous situation, such as when fire responders are on a fireline or when employees operate motor vehicles in the interests of meeting management objectives. Sometimes the risk to be addressed is that borne largely by communities that are collocated with hazardous fuel environments. Risk management through its various processes (e.g., risk assessment, analysis, monitoring, co-management) aligns with accountability principles by providing the formal structure by which risk-related decisions can be made *inclusive* with respect to stakeholders, *material* with respect to both the organization and stakeholders, and *responsive* to those issues that stakeholders face.

Risk Management in Practice: Values, Formalism, and Uncertainty

People routinely make RM decisions every day. For example, as a matter of practice when driving a motor vehicle, almost all motorists choose to buckle their seatbelts and put their children in restraining seats. However, these RM decisions are not formal.

Formal RM is done in accordance with specific rules and procedures that are sanctioned in some way. In the case of the formal RM that we have been discussing here, the principles derive from broadly held standards and guides associated with a base of scientific understanding. Formal RM practiced this way is characterized by attention to established procedures, comparison of alternative decision options, documentation of procedural results, and ongoing monitoring of outcomes and their relationship to pre-decisional conditions. RM practiced in this manner yields a continuous improvement

in risk-based decisionmaking as well as the accumulation of a rich base of risk-related information about ongoing monitoring and related research.

What would formal RM look like if the Forest Service were doing it? To some it might look familiar, and it has much in common with current practice in other business areas (e.g., the National Environmental Policy Act, or NEPA). Managers across all levels of the agency would follow a structured process that provides an objective basis for decisions, helps avoid common errors, fosters communication and inclusion of relevant decision factors, helps evaluate tradeoffs, and improves transparency. Managers would begin this process by asking the right types of questions and ensuring that analyses and assessments answer the questions they are intended to answer. Getting the question right provides the focal point for all subsequent problem-solving efforts. Managers would embrace the responsibilities of identifying problems and opportunities, estimating risks, evaluating risk management options, implementing risk control measures, and monitoring outcomes. Managers would find themselves regularly and iteratively posing the following basic risk management questions:

- What is the problem (i.e., what is the risk or opportunity faced) and what is its impact on objectives?
- What information (e.g., uncertainties, consequences) is necessary to address the problem?
- What actions (i.e., risk management options) can be taken to alter the exposure to or the consequences of the risk, and what are their tradeoffs?
- Which risk management options are most likely to achieve objectives?
- Are they working?

Three key elements of the RM process are risk assessment, risk management options, and risk communication (fig. 1). These elements are interrelated and support one another, but rely on different sources of information and therefore involve different groups of individuals. Assessment is focused on evidence and science-based information. Evaluation and selection of risk management options further involves policy and values-based information. Communication entails a two-way exchange of information about science, values, and perceptions. Successful RM and integration of these three elements depends on the Forest Service clearly establishing organizational values and objectives, which we address first.

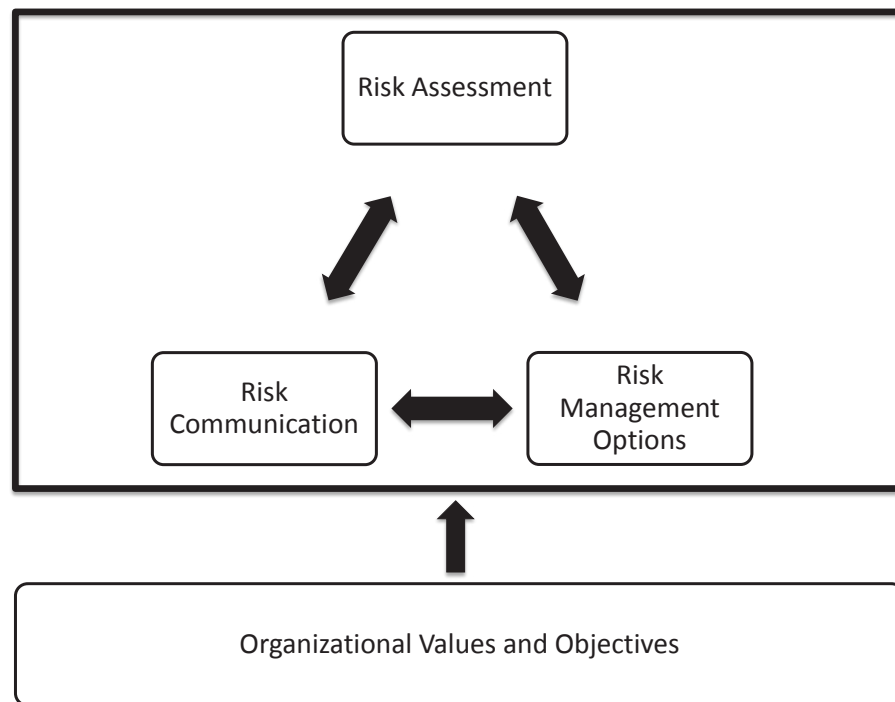


Figure 1: Risk assessment, risk management options, and risk communication are three primary components of RM; all are influenced by the foundational importance of organizational values and objectives. Source: Tom Zimmerman

Organizational Values and Objectives

The essence of RM is about organizational values; without clear values, processes and decisions become muddled. An organization must be able to describe, characterize, and communicate its foundational values. It requires facing questions such as what you hope to achieve now and in the future. The national forests are incredibly valuable to the U.S. public—the challenge for managers is to determine the best strategies to grow that value under uncertain disturbances, increasing population demands, and changing societal preferences. RM is a powerful tool to evaluate the portfolio of management actions that can provide the best return to the public for the investment.

Objectives are how values are portrayed within plans and actions. A key step in ensuring high-quality decisions across all organizational levels is establishing clear RM objectives. This step may seem trivial, but it is often done poorly. For example, past reviews of fire management objectives have found instances of inconsistency, approaches that ignore risk, and a lack of specificity. Good objectives are specific, complete, meaningful, measurable, congruent, and attainable. They are defined for the specific decision at hand, not for universal use, and should therefore lead to specific strategic choices. Good objectives clearly identify desired outcomes over space and time. They recognize and balance the inherent risk-risk tradeoffs associated with management. Gifford Pinchot recognized these inherent challenges when he stated, “[W]here conflicting interests must be reconciled, the question will always be decided from the standpoint of the greatest good of the greatest number in

the long run.”³ Good objectives recognize that minimizing today’s risk can decrease the value of the resource in the future.

Identifying overarching objectives for the management of public lands in the United States presents a major challenge. This stems from the critical differences among members of society in what they desire from their lands. Although broad agreement on objectives is unlikely, some efforts could be highly fruitful in identifying and achieving shared societal goals for wildfire management. For example, the Forest Service could better describe how the consequences of its current wildfire management approach affect values associated with public lands. The agency could incorporate potential outcomes into land and fire management plans. Partnerships such as the Collaborative Forest Landscape Restoration Program have demonstrated that even though consensus may be rare, broad agreement can be reached to promote and enhance shared objectives for better public land management. Improving the agency’s ability to identify and establish clear objectives for wildfire management at all scales will improve effectiveness in managing wildfire, assure that public investments are well spent, and justify the appropriateness of established objectives to the fire responders who are risking their lives to protect lives, property, and land.

Risk Assessment

At root, risk assessment generates answers to some very basic questions: What might happen, how could it happen, how likely is it to happen, and what would the consequences be if it did happen? The process is ideally systematic, logical, and evidence based, and provides managers with the best possible description of risks faced in their specific decision context. The four primary steps of risk assessment are identifying the hazard, analyzing the exposure of resources and assets to the hazard, analyzing the resultant effects given exposure, and characterizing risks in a meaningful way (see Box 2). Consider a prefire risk assessment applied for a given landscape. The following questions are likely to be asked:

- Where are wildfires likely to occur, with what probability, and at what intensity?
- How large are fires likely to grow?
- What are the spatial patterns of fire likelihood and intensity?
- Which resources and assets have the greatest exposure to wildfire hazard?
- What are the likely effects to resources and assets at different fire intensity levels?
- Where might fires cause harm/damage, and where might they lead to benefits?
- How is wildfire risk distributed across the landscape?

How the assessment process is carried out may very well be as important as the results themselves, ideally fostering trust and improved lines of communication. Again, it begins by getting the questions right, and then proceeding to answer them. Clearly documenting this process is essential to provide a basis for explaining

³ <http://www.fs.fed.us/greatestgood/press/mediakit/facts/pinchof.shtml> [Accessed April 11, 2016].

Box 2: A Primer on Risk Assessment

Risk assessment is at the core of risk management and is a *process* that is made up of several component processes. In the most general form these are:

- **Hazard identification:** The process of finding, recognizing, and describing the hazards that could affect the achievement of the objectives an organization seeks to obtain or that could lead to losses of the organization's valued resources.
- **Exposure analysis:** The process of identifying the exposures to which various resources or assets could be subjected.
- **Consequence analysis:** The process of identifying the nature and range of the consequences that would occur if resources or assets were exposed to various hazards (also called effects analysis).
- **Risk characterization:** The process of integrating information about hazards, exposures, and consequences, and representing that information in terms of risk. These representations can include likelihoods, magnitudes, and impacts on an organization's objectives. They can be composed of *quantitative* information, *qualitative* information, or both. This aspect of risk assessment also includes *risk analysis*, a process that is used to understand the nature, sources, and causes of risk as well as the assessment of risk magnitude. One form of gauging the magnitude of risk is *expected value*: a measure of risk obtained by weighting a consequence by its likelihood of occurrence.

Note that the general risk assessment process is scalable; in other words, the same basic ingredients and steps can be applied from local, project-level planning all the way up to national-scale prioritization efforts. To be done well and at a level commensurate with the consequences of fire, significant time, effort, and capacity are typically necessary.

Risk assessment can also be considered as a product, one which provides a focused collection of data, information, results, and reports that characterize risks at the appropriate scale and context. Additional terms associated with risk assessment and other aspects of risk are defined in Thompson et al. (2016).

findings and justifying any risk management actions taken. Involving the right people—often bringing in multiple disciplinary perspectives (e.g., fire ecology, wildlife biology, and hydrology)—can ensure answers to the questions will be informed and robust. Openly identifying and addressing uncertainties and sensitivities promotes transparency and ensures managers have the appropriate level of confidence in various courses of action.

Risk Management Options

Risk management options are alternative strategies or actions that could be undertaken to prevent or mitigate risks and ultimately achieve risk management objectives. The overall process entails developing, evaluating, comparing, choosing, implementing,

and monitoring risk management options. Managers must ensure sufficient resources are allocated to find timely solutions, as well as to evaluate whether such an investment is worthwhile given constraints, objectives, and competing priorities. Not all risks can be effectively controlled, and not all risks are worth taking (e.g., exposing fire responders to hazardous conditions to protect low-value timber or low-quality habitat).

What do you “manage to”? There are essentially three options: probability, consequence, and risk (an amalgam of probability and consequence). We will consider the third: risk itself. From an economic perspective we can think of risk as a function of probability and consequence. It is generally indexed by a metric based on weighting consequences by their likelihood of occurrence. Most commonly, we multiply a consequence by its probability. This results in what is referred to as an “expected value” or “expected loss.” Taking fire as an example, a home worth \$500,000 that has a 10-percent probability of being destroyed by fire (the consequence) represents an expected loss of \$50,000 (i.e., $0.10 \times \$500,000 = \$50,000$). One of the challenges with managing to this concept is posed by situations where the consequence is very high but the probability is very low. These low-probability, high-consequence events have an expected loss that may be relatively small compared to the potential actual consequence. The seriousness of the loss in terms of its catastrophic potential may appear to be significantly underweighted.

Managing to probability means that management efforts are focused on reducing the likelihood of an unwanted event, its consequences, or both. For example, when forest managers restrict industrial activity on managed lands (e.g., timber harvesting), they are in effect managing to probability by reducing the chances that industrial activity would result in an ignition. Likewise, closing recreational facilities and taking similar actions that restrict public access lower the likelihood of fire occurrence.

Alternatively, managing to consequences focuses on limiting the range or severity of consequences that might occur as the result of an unwanted event. Homeowners, for example, are essentially managing to consequences when they abide by some of the Firewise principles that limit the damage a wildfire would do to their home if the wildfire reached their property.

In practice, it is generally preferred to explore risk management from all three of the perspectives summarized above. Each perspective leads to a richer set of management options.

Developing good sets of options for risk management can be challenging, especially in contexts with action-oriented personalities doing “what needs to be done.” It is not uncommon for managers to tend to favor approaches they are familiar with or have the authority to implement. Yet best practices for structured RM decisionmaking require consideration of a broad array of alternatives, along with analysis of their respective tradeoffs and likelihoods of success. Put another way: How can you be sure you have selected the best option if you did not consider many options? One common consequence of unaided decisionmaking is that managers are left without a rich option set. If they intuitively evaluate options and reject some before doing a structured analysis, they will exclude potentially good options from the set of those evaluated.

Developing high-quality options can be particularly difficult in the time-pressured environment of wildfire response. Ironically this may be the decision environment in which having multiple options is the most critical given the uncertainty and magnitude of consequences. From this perspective, prefire assessment and response planning

are essential steps in the incident RM context. The first step is to establish clear and actionable objectives. The second step is to proactively consider alternative options for managing a future fire while leveraging features such as fuel treatments, previous fires, roads, and ridgetops. It may be the case that what “looks good” immediately as the “only option” is actually one that discounts or does not take account of more difficult attributes of the decision problem, such as the temporal occurrence of consequences.

Evaluating options and determining the “best” is premised on establishing meaningful and measurable criteria that distinguish options along differences that matter. This is undoubtedly—and by design—a value-laden step, incorporating aspects such as policy and the relative importance of various objectives. Making comparisons by using a common currency can simplify, but it is not likely to be applicable in all circumstances, requiring balancing of noncommensurate tradeoffs.

Indeed, in most real-world problems, we strive to achieve multiple objectives. Sometimes there is a dominant solution that achieves the maximum on all dimensions. More often, however, such is not the case and we can, under one alternative, realize more of one objective than another. The problem is one of understanding the course of action (e.g., alternative, option, or prospect) that gives the best tradeoff between the objectives. In this context, tradeoff can be taken as a general concept: more of one means less of another. The point at which more of one offers too little of the other, or is not worth the lessening of the other, is the point we seek to clarify and understand. One of the strengths of formal RM is that it makes explicit the identification and attainment of the tradeoffs between objectives through tradeoff analysis, thereby producing a balanced perspective on the RM problem at hand. In this way, the decision process by which complex alternatives are evaluated in light of one another and their respective tradeoffs is made transparent and communicable.

Tracking decision outcomes is admittedly difficult in wildfire management. Uncertainties are substantial, large fires are rare phenomena (although potentially increasing in probability in some areas), and ecosystem-relevant timeframes may be long. These points highlight the importance of investing in monitoring, and creating a data-driven system of accountability to evaluate and modify performance. These points also underscore the utility of periodic risk assessments to evaluate current risks given recent actions such as fuel and restoration treatments as well as disturbances.

Risk Communication

Risk management best practices call for a transparent and open process, requiring lines of communication across managers, risk analysts and assessors, and relevant stakeholders. Goals of risk communication include improving understanding of the risk and associated RM options, enhancing trust in the decisionmaking process, and promoting awareness of and participation in risk management decisions. Effective risk communication is an interactive exchange of both science-based and value-based information. It takes place throughout the RM process and provides the basis for arriving at and explaining RM decisions. Ineffective communication can come with a cost. Lack of trust could lead to conflict and derail implementation of RM actions. Lack of understanding could lead to individuals and groups not taking action or taking the wrong actions to reduce risk.

The two main forms of risk communication are *internal* and *external* communication. *Internal* communication occurs within the boundaries of an organization, though this may also include its contractors, cooperators, and other operational stakeholders. It is part of a larger management framework and requires coordination and collaboration between assessors, analysts, and managers. One of the key functions of internal risk communication is to foster and maintain a clear and resilient relationship between supervisors and subordinates with respect to RM decisions and their potential outcomes. Frequent engagement is important to correctly pose and understand the RM questions, assess the effectiveness of RM options, communicate uncertainty, and document the process. Properly done, internal risk communication should lead to cooperative and supportive management relationships across all levels of the organization.

External risk communication occurs when an organization engages those outside of itself in risk issues. Generally this means the public in its various forms, including other governmental organizations (e.g., city or county councils), nongovernmental organizations (e.g., special interest groups), and those affected by an organization's risk-related decisions (e.g., homeowners). As a rough guideline, external risk communication becomes important to an organization when its decisions and activities involve the exposure of others (outside the organization) to the potential for harm. Management of wildland fire falls clearly into this domain.

Particularly important is clear communication about the effectiveness of various RM options and what residual risks remain, so that stakeholders have a better sense of their own risk management responsibilities and what actions they can take to reduce risk. Take, for example, the observation that the characteristics of the home ignition zone are the main factors that determine home loss. Effective risk communication would highlight this finding and stress that actions such as hazardous fuel treatments near the wildland-urban interface do not eliminate risk or the need for homeowner action.

Some questions to guide development of risk communication strategies are:

- Why are we communicating?
- Who are the stakeholders and audiences we are trying to reach?
- What do we want them to know?
- How will we communicate, how will we listen, and how will we respond?
- How will we determine the quality and effectiveness of risk communication?

Objectives and Options (Ends and Means) at Different Scales

It is important to recognize that how objectives are defined and what types of RM options are available will vary depending on who is asking the questions and their respective level in the hierarchy of land and fire management. It is also important to recognize that fire management objectives are largely vectors for achieving broader land and resource objectives. Developing a useful set of objectives requires understanding how objectives relate to each other, and separating ends from means. Ends relate to why something is important, and means relate to how it could be achieved.

Figure 2 illustrates how the ends and means vary with the relevant fire management scale. The box in the upper left of the figure represents the uppermost levels of the Forest

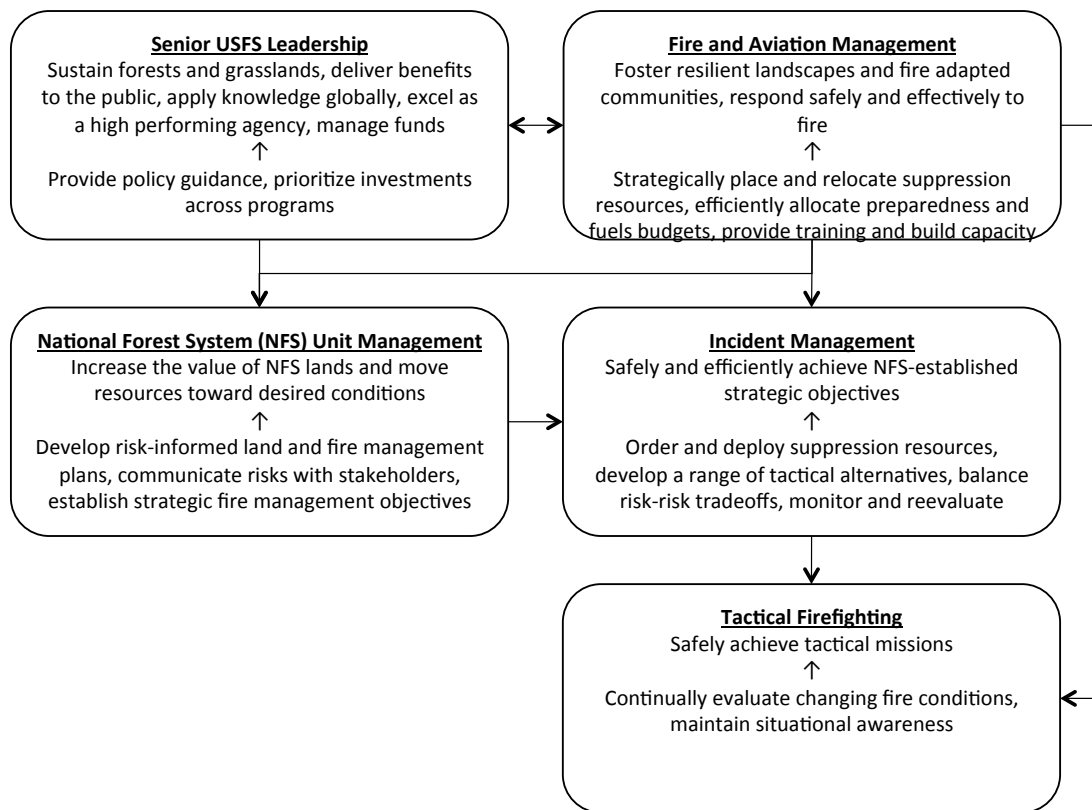


Figure 2: Ends and means across fire management scales

Service, with organizational objectives outlined according to the 5-year Strategic Plan. Providing policy guidance and prioritizing investments across programs are examples of actions that can be taken to ensure attainment of objectives. These actions must consider the full spectrum of fire and other disturbance events that may occur. The bottom right of the figure represents actions on individual fire events, where fire responders embrace the “10 and 18” to safely achieve tactical missions. In between these extremes, Fire and Aviation Management leadership, National Forest System (NFS) managers and staff, and Incident Command System staff are all participants in organizational RM processes and decisions.

Understanding Uncertainty and Embracing Probability

Uncertainty is essentially a lack of information, which is pervasive in fire management. As examples, we may not know the exact timing or location of future ignitions, the effects of fire on a range of ecosystem services, or the relative effectiveness of alternative response strategies and combinations of fire response resources. Does the presence of uncertainty mean that our hands are tied? Far from it. What can we say about something we do not fully know or understand? Quite a bit, actually.

There are many different ways to describe and analyze uncertainties that can be helpful in different modeling and decision contexts. For our purposes here we will focus on two characteristics: the underlying cause or nature of uncertainty and the level of uncertainty. First, we can think of uncertainty as arising from limitations of knowledge (e.g., data gaps, measurement error, understudied phenomena) or from the inherent variability

of human and natural systems (e.g., shifts in political winds as well as actual winds). Understanding the nature of uncertainty can help us better cope with, and where possible, reduce uncertainty. In the case of uncertainty about a source of knowledge, we may be able to reduce that uncertainty through additional research or monitoring. Even though the uncertainty of inherent variability is not considered reducible, we can find improved ways to statistically describe climate and weather patterns, for example.

Second, the *level* of uncertainty describes where we find ourselves along a continuum from total determinism to total ignorance. When we have perfect information, there is no uncertainty. When we are completely ignorant, we are not even aware there is an uncertainty that we are not aware of (i.e., the unknown unknowns). We can think of this spectrum another way, in terms of *partial knowledge*. Let us return to the idea of uncertainty surrounding future ignitions. Although we may not know the exact location or timing of future ignitions, we probably have a good sense of how often we typically experience fire on the landscape, and of which areas are more receptive to the growth of large fires given topography, fuels, predominant wind directions, and other factors. We can—and should—act on partial knowledge. In fact, we do it all the time. RM provides the direct basis to do this in a formal, structured way.

Perhaps the most fundamental principle necessary to become a risk manager is a strong belief in a probabilistic world. This is a belief that the relationship between the actions you take and the outcomes that occur can never be known for certain beforehand, albeit at times the likelihood may be very, very high (or low) for what is expected. To reside in this world as a risk manager is to develop a comfort and fluency with probabilistic reasoning and communication. Probability is the language of uncertainty and its mastery is a part of the process by which an organization grows its risk management capacity. Like all languages, it has rules, syntax, semantics, and definitions. At times, it is based on quantitative information derived from past experience or models of processes. At other times it is based on qualitative information such as personal assessments or experts' judgment. The good news is that we all learn, through our culture, some of the basics of this language and recognize its applicability to daily life. The task ahead is to build upon this foundation and to refine our application of probabilistic thinking to the organization's RM decisions.

How to Become a Risk Management Organization

In this section, we chart a course for how the Forest Service can become an RM organization. We believe the Forest Service is well-positioned to make this transition. Forest Service leadership has stated a goal of embracing RM, managers are increasingly interested in learning about and applying RM, and research has developed a rich set of data, tools, and models to support a range of risk-based decisions. It is important to note that the next steps in RM are likely to require significant change—not only in the way we examine and address problems, but perhaps also in the structure of the agency itself.

This is not simply a problem of the Federal Government. Many of the most damaging wildfire events over the last several decades have included only limited Federal lands, and many of the drivers of wildfire response on Federal land are related to values that reside across the public land boundaries on private lands. Thus, engagement with partner

agencies in our transformation process will be required. RM is a vehicle that can help design, evaluate, and guide alternative management structures that will be required in order to alter the current trajectory of wildfire related loss.

What might the desired horizon toward which the Forest Service is moving look like given where it is today? We envision an organization where the idealized version of incident response depicted in Box 3 is considered the norm rather than the exception. We envision an organization that is more comfortable acknowledging and addressing uncertainties, is well versed in analyzing probabilities and consequences, assesses and treats risks across multiple domains, and documents decisions across organizational levels. We envision an organization that recognizes that safety management is a question of what you are going to do right now, while RM additionally asks what you might do far into the

Box 3: Risk-Based Incident Response: A Vision

In this idealized version of incident response, RM principles and practices are put into place well in advance of an ignition. Fire management decisions are based on a risk assessment that characterizes the risk in terms of hazards, probabilities, exposures, and consequences, that serves as a basis for evaluating alternatives, and that can ultimately support a risk-informed decision process. Land and fire management objectives are clearly defined, response scenarios have been considered, and risk-risk tradeoffs are explicitly acknowledged. Central elements of a structured RM approach to incident response are outlined below:

- **Timeliness:** Assessments have been performed recently enough to provide sufficient information on current conditions and to provide relevant strategic guidance.
- **Specificity of Values-at-Risk:** Highly valued resources and assets (HVRAs) relevant to land management objectives have been identified and mapped.
- **Relative Importance of Values-at-Risk:** Efforts to protect or enhance HVRAs is based on a set of priorities that reflect the relative importance of those HVRAs, in relation to other concerns like fire responder exposure and suppression expenditures.
- **Specificity of Consequences:** Identification of consequences of HVRA exposure to fire (i.e., analysis of fire effects or susceptibility)
- **Probability of Consequences:** Qualitative or quantitative assessments of uncertainty
- **Comparison of Alternative Strategies:** Ideally a comparison of two or more risk management strategies, and an evaluation of how likely they are to be successful
- **Stakeholder Involvement:** Helps ensure that the decisionmaking process is shared and that all relevant potentially impacted HVRAs are considered.

Box 4: Getting Started

In the near term, several steps could help things move in a positive direction. By near term, we mean that steps such as these could probably be implemented in 12 to 18 months.

1. Review the current level of adoption of RM principles and existing tools within the Forest Service and other relevant Federal agencies.
2. Based on this review, perform a needs assessment or a gap analysis to identify key areas of needed improvement; this evaluation should focus on elements like governance, culture, process, people, knowledge, and systems.
3. Develop a "Risk Management Learning Journey" for the Senior Leadership Team similar to the "Safety Learning Journey" and in doing so engage leadership from other Federal agencies (and possibly private business) that have adopted and embraced enterprise RM.
4. Conduct an enterprise-level risk assessment with the Senior Leadership Team to explore systemic risks and opportunities (including wildland fire, but also much broader).

future. We envision an organization that invests in developing a risk-informed workforce and culture.

Moving toward this horizon requires a forward-looking perspective, getting ahead of future problems in both time and space. It will require recognizing that the nature of RM questions varies with context and scope. It will require a commitment to learning, to analytical rigor, and to developing a system of accountability. It will require getting started sooner rather than later (see Box 4).

In the longer term, three primary areas warrant emphasis as keys to an effective organizational approach to RM: leadership, education and capacity, and assessment and planning (fig. 3). As illustrated in the Venn diagram, these areas overlap and are interrelated. In the following bulleted lists we outline a preliminary set of best practices and recommendations that relate to these three emphasis areas. Some of the elements we describe may already be well established in practice, but we include them for the sake of completeness. Others may require taking further steps to improve business practices. Of these, some steps could be completed in as little as 3–5 years, whereas others may take

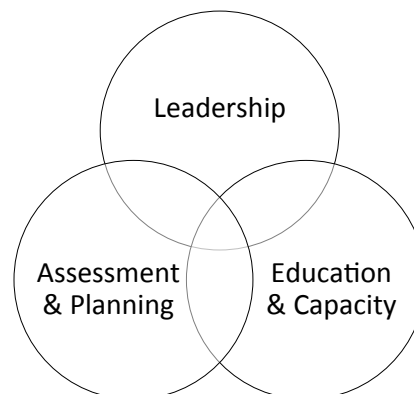


Figure 3: Three primary long-term emphasis areas for successful RM

5–10 years or longer. Moving forward will require concrete articulation of what is desired and commitment of sufficient resources.

Leadership

- Take ownership of, embrace, and endorse change.
- Embrace RM principles and practices and expand their application throughout the Forest Service beyond fire.
- Do not delegate RM decisions down the chain but rather support and participate in RM decisions at all organizational levels.
- Develop and enforce a robust system of accountability that aligns with the principles of sustainability, inclusivity, materiality, and responsiveness.
- Communicate and share management of risks with stakeholders and partners.
- Foster stronger interactions between Research and Development, State and Private Forestry, and the National Forest System.
- As part of leadership development, foster a capability for effectively managing problems that have high uncertainty and complexity.

Education and Capacity

- Develop criteria for defining and prioritizing issues and geographic areas where risk assessments are needed.
- Invest in translational research that helps the field understand how to put best available science into operation and how to effectively use existing tools and models.
- Restructure and reprioritize investments in research and development to match the needs of an RM organization.
- Develop and implement support for managers to acquire new skills relating to risk assessment and management.

Assessment and Planning

- Ensure plans are consistent, collaborative, clear, comprehensive, spatially and temporally scalable, informed by best available science, and flexible and adaptive.
- Incorporate landscape risk assessment into planning efforts, based on the concepts of characterizing highly valued resources and assets, their exposure to fire and other disturbances, and their respective susceptibility to benefit/loss as a result of exposure.
- Reframe desired conditions from a singular end point to a range of outcomes considering how environmental variation, disturbance, and management actions may alter trajectories toward end points.
- Revise planning efforts to account for changes in landscape conditions after large disturbance events, and to accommodate improvements in assessment and monitoring.

- Delineate strategic response zones that provide guidance for incident response based upon potential fire behavior and spread, consequences, and other factors .
- Evaluate “what if” scenarios to prospectively identify areas where alternative response strategies and tactical actions might be most appropriate.
- Develop and implement high-fidelity pre-incident simulations and hold incident management accountable for applying what was learned from simulations to actual incident response.

Education and Capacity Plus Assessment and Planning

- As a near-term solution, assemble and deploy a set of interdisciplinary consulting teams to provide the necessary expertise and guidance in risk-based decision support.
- As a long-term solution, develop institutional capacity and a risk-informed workforce through training and other forms of knowledge building.
- Tailor and orient development of training around major categories of planning and decisions (e.g., forest plan revision, project development, and incident response).

Leadership Plus Education and Capacity

- Develop risk assessment and management curricula for senior managers to ensure they are conversant in RM concepts and principles, and can therefore fully and knowledgeably participate in processes of problem formulation, planning, and decisionmaking.
- Adopt the paradigm of a military officer corps for line officer corps: recruit high-potential candidates and enroll them in officer training that emphasizes development of a scientific knowledge base and strong analytical skills.
- Appoint a “risk ambassador” or “risk czar” to the national leadership team; the person in this position would be required to stay abreast of the state-of-the-art in RM, and would identify and address risks across the entire organization, not just a single unit.

Leadership Plus Assessment and Planning

- Engage in and support land and resource management planning efforts.
- Ensure that planning efforts are asking the right questions to address all types of risks, and are relying on best available science for assessment.
- Ensure that planning documents (land and resource management plans, forest management plans) provide clear, risk-informed objectives based on fundamental fire ecology and are developed in the context of guidance for incident response, and conversely that incident response objectives and strategies are consistent with and tier to objectives established in these planning documents.

Leadership Plus Education and Capacity Plus Assessment and Planning

- Ensure leadership commits to providing guidance and sufficient resources for improving education and capacity, and assessment and planning.
- Develop “centers of excellence” where managers at all levels can observe, interact, and acquire risk management capabilities.

The path forward will present both challenges to overcome and opportunities to leverage. What might the road look like? We begin by addressing some potential barriers that could inhibit the Forest Service’s transition to an RM organization:

- Incentives: It is well established that fire managers’ decisionmaking is influenced by a suite of internal and external factors that tend to encourage high-cost, status quo suppression-oriented strategies; improved guidance from planning documents, accountability for decisions, and open support from higher level management will help alleviate these pressures.
- Decision biases: It is also well established that humans tend to fall victim to a range of suboptimal decision biases and heuristics in time-pressured and uncertain decision environments; upstream planning and thoughtful design of decision support can help improve decision processes.
- Funding issues: Budgetary concerns are prominent and myriad, and relief may come from legislative action; but internal reorganization to improve preparedness and response may also be necessary, for instance, to interrupt the feedback loop (where base 8 funding is insufficient to fund employees, who then have the financial incentive to work on fires, which bring in additional funds but often lead to higher costs that eat into future base 8 funding).
- Regulations: Air quality concerns are perhaps the most limiting; a concerted effort by the Forest Service and other fire management organizations is likely necessary to educate regulatory agencies on the inevitability of fire and smoke—such that zero smoke is not an option—and on the benefits of preventive actions such as prescribed fire.
- Co-management of risk: social license may be difficult to attain, objectives may be too incompatible across landowners and jurisdictions, and stakeholders may be reluctant to take necessary actions; the Forest Service must be willing to disinvest in areas where it has a limited ability to measurably reduce risk (i.e., it shouldn’t take bad bets).

Additionally the Forest Service will have opportunities to capitalize on in order to introduce and expand risk-based ideas into the organization:

- RPA assessment: Current analysis and reporting under RPA (Forest and Rangeland Renewable Resources Planning Act of 1974) might be the area most readily available and amenable to adoption of RM principles; the transformed assessment process would use a similar set of elements but adopt a more systemic approach that would consider social changes and trends and would use probabilistic modeling.

- Forest plan revision: Upcoming and in-progress work updating land and resource management plans provides numerous opportunities to integrate state-of-the-art landscape risk assessment
- Existing tools: Decision support tools like WFDSS already provide a wide range of information and analysis; these systems are evolving with the best available science, and can be further tailored to structure decisions, provide the most useful content, and facilitate prefire planning.
- Identify successes: RM principles have been adopted at all planning scales (see Box 5), and these instances can be identified and shared; examples include consequence assessment on the Clark Fork Complex (incident) and use of landscape risk assessment to delineate strategic response zones in the Southern Sierras NFs (forest plan revision) and to develop the Rogue Basin Cohesive Forest Restoration Strategy (landscape planning and co-management of risk).
- Build on successes: The Forest Service at all levels, as well as its partners, has been designing and using risk assessment products for years; this activity has nearly always been an organic and bottom-up process, but investment from the top down could synthesize lessons learned, identify room for improvement, and streamline processes for expanded application
- Co-management of risk: Though listed as a potential barrier above, this is also an opportunity; efforts like the Cohesive Strategy and the Collaborative Forest Landscape Restoration Program are successfully bringing multiple stakeholders and perspectives to bear. Establishing a shared understanding of risks and concerns can help identify who can most efficiently mitigate risk factors, and can stimulate joint investment in mitigation.

Box 5: Getting It Right: An Example From Arizona

The emergence and expansion of managing natural fires for hazard reduction and ecological benefit provides a positive example of the application of RM to achieve improved land management outcomes. The Kaibab National Forest (NF) in Arizona began implementation of this practice in the early 2000s. Research conducted by Northern Arizona University (NAU) helped Forest Service staff to recognize the need for reintroduction of wildfire to improve landscape health and reduce wildfire risk throughout most of the NF. Forest Service and NAU employees worked diligently to build public support through a range of public outreach efforts along with increased off-season planning. Consideration of wildland fire use was first formally recognized through a signed NEPA document that amended the Forest Plan in 2000. The first application occurred in 2003 (in 2009 Federal Fire Policy Reinterpretation eliminated consideration of wildland fire use). Between 2003 and 2014 the Kaibab NF averaged almost 12,000 acres (4,800 ha) of resource benefit fire per year. In 2014 six fires were managed for resource benefits totaling 28,640 acres (11,600 ha) with an average cost of only \$46 per acre (\$114 per ha)—considerably less than typical management costs for fire suppression or even prescribed burning. In fact since 2003, the Kaibab has managed more than twice as much area under resource benefit than under some form of suppression objectives (143,500 acres or 58,100 ha compared to 63,600 acres or 25,800 ha). Managed fire has exceeded prescribed fire during the same period (143,500 acres compared to 93,750 acres or 38,000 ha).

This is not to say that the Kaibab has fully implemented all aspects of RM that we consider in this report. As we stated earlier, RM is a journey and not an end point. By examining some of the primary concepts we espoused earlier in this paper, we can evaluate how many of the RM concepts have been achieved and where there are still more opportunities.

- Implicit → explicit: The Kaibab fire staff was directly involved in updating the Forest Land and Resource Management Plan, which includes clear intent to allow naturally occurring wildfire on most of the land base. This guidance has been incorporated into the spatial fire planning layer within the Wildland Fire Decision Support System (WFDSS) to help inform decisions. Appropriately, decisions regarding fire management strategies of each ignition still require significant managerial discretion based on weather and climate factors, time of season, and fire location.
- Informal → formal: Requirements and guidance on monitoring and adaptive management planning are specifically addressed within Chapter 5 of the revised forest plan. Additionally, the Kaibab NF staff schedules annual meetings with the public and conducts internal reviews of intended fire management activities. However, the review process is not formalized, nor is the decision process for determining whether ignitions are to be managed for resource benefits.

Box 5: continued.

- Intuitive → analytical: The Kaibab NF staff has developed datasets for fuel conditions, HVRAs, fire management zones, and management features that will inform decisionmaking when incidents occur. Before each fire season NF managers conduct informal analyses and discuss likely strategies and opportunities. These steps could possibly be more structured and streamlined.
- Reactive → proactive: Kaibab NF managers plan and prepare for upcoming wildfire seasons with a clear intent of increasing the amount of beneficial fire on the landscape.
- Local interests → organizational interests: Managing wildfire for resource benefits is a poorly rewarded activity for field employees but recognized as a necessity by the Forest Service within the 5-year Strategic Plan and other guiding documents. Kaibab NF employees have worked closely with local community members to help align local and organizational interest in the promotion of managed wildfire where appropriate.
- Short-term perspective → long-term perspective: Within the Forest Service short-term considerations of fire risk typically result in aggressive suppression, which in some contexts has led us down the wildfire paradox path. Through use of wildfire to achieve land management objectives the Kaibab NF is well on its way to breaking the cycle of an increasingly challenging wildfire management environment and greater risk to highly valued resources and assets.

Conclusions

In this report we set out to summarize RM concepts, principles, and practices, contextualized to the wildland fire management challenges the Forest Service faces. Admittedly we focused more on the “what” and the “why” questions: What is organizational, or enterprise, RM, and why would the Forest Service benefit from more formal adoption of RM? This was by design; we feel it is essential to develop a shared understanding prior to developing shared strategies for improvement. As we continue this journey, the “how” questions will gain prominence, will benefit from the collective wisdom of Forest Service employees and stakeholders, and will require commitment. We hope the course we outlined in the previous section provides a useful jumping-off point for discussions of how best to change, and ultimately helps improve agency decisions and outcomes.

Management Implications

Trajectories of increasing cost and loss lead to concerns over an ever-worsening path for wildland fire management, particularly when considering factors like climate change and expanded exurban development. There is neither a one-size-fits-all solution nor a readily available panacea. Additional resources and capacity could help, but only if used wisely and efficiently. What could also help is a fundamental reevaluation of organizational processes, actions, and systems of accountability. The status quo is

unsustainable. Risk management, we argue, provides the best opportunity to evaluate and improve business practices across all levels of the Forest Service, and better achieve its mission.

We believe RM also provides the best opportunity for learning and continual improvement. Change within the Forest Service will not be immediate nor will it be easy, and will require significant investments of time, resources, and willpower. We hope the ideas presented in this report facilitate this process of transformation. We are committed to helping this process as best we can, and will try to bring the best available science and information to bear in ways that are timely and relevant to Forest Service needs.

Annotated Bibliography

There exists a large and growing body of peer-reviewed literature focusing on various aspects of fire management and risk assessment, among other topics. The authors would be happy to provide further detail and recommend additional citations. Here we focus more on foundational sources for issues related to uncertainty, risk, analysis, and management.

Calkin, David E.; Cohen, Jack D.; Finney, Mark A.; Thompson, Matthew P. 2014. How risk management can prevent future wildfire disasters in the wildland-urban interface. *Proceedings of the National Academy of Sciences*. 111(2): 746–751.

This paper is limited in scope to concerns surrounding home loss in the wildland-urban interface (WUI), but it provides a useful review of risk management concepts. In particular it clearly defines objectives, links ends with means, and identifies which actors have responsibility for implementing various options, in support of efficient co-management of risk.

Calkin, David E.; Thompson, Matthew P.; Finney, Mark A. 2015. Negative consequences of positive feedbacks in US wildfire management. *Forest Ecosystems*. 2(1): 1–10.

This paper summarizes historical and modern wildland fire management contexts, describes the drivers of suppression response, and highlights problems associated with existing management paradigms.

Gigerenzer, Gerd. 2014. *Risk savvy: How to make good decisions*. New York: Viking. 336 p.

This is a very readable review of how humans, even experts, often make poor decisions in contexts involving probability and risk. Although the examples largely relate to the medical industry, parallels are apparent to land and fire management. Gigerenzer helps demystify some of the more esoteric elements of probability theory and psychology, and proposes some fairly simple approaches that might have value in how we frame and understand fire management decision contexts.

ISO. 2009. ISO 31000:2009(E), Risk management—principles and guidelines. Geneva, Switzerland: International Organization for Standardization.

<http://www.iso.org/iso/home/standards/iso31000.htm> [Accessed March 30, 2016].

ISO is an independent, nongovernmental organization that brings together experts to develop “international standards” to improve products, services, and systems, and to ensure quality, safety, and efficiency. Standards are developed with a consensus-based approach incorporating multiple stakeholders and experts from around the globe. ISO takes an organizational perspective to risk management, which has an obvious and direct relation to our focus in this report on helping the Forest Service become a risk management organization. We relied heavily on ISO in developing this report, notably with respect to the concepts and principles of risk management. The following two related standards are also useful references:

ISO Guide 73:2009, Risk management—Vocabulary. 15 p.

http://www.iso.org/iso/catalogue_detail?csnumber=44651 [Accessed April 11, 2016].

ISO/IEC 31010:2009, Risk management—Risk assessment techniques. 176 p.

http://www.iso.org/iso/catalogue_detail?csnumber=51073 [Accessed April 11, 2016].

Morgan, M. Granger; Henrion, Max. 1990. *Uncertainty: A guide to dealing with uncertainty in quantitative risk and policy analysis*. With a chapter by Mitchell Small. New York: Cambridge University Press. 332 p.

This book provides a comprehensive review of uncertainty, including conceptual definitions of the origins and types of uncertainty, how to quantify uncertainty, and how it can influence analyses and decisions. Although some chapters can be rather technical, and some of the examples are dated, the introduction in particular provides excellent guidance for policy analysis.

National Research Council. 2009. *Science and decisions: Advancing risk assessment*. Washington, DC: The National Academies Press. 424 p.

The National Research Council is the principal operating agency of the National Academy of Sciences and the National Academy of Engineering, with the purposes of expanding knowledge and advising the Federal Government on scientific and technical matters. This book was written in response to a request by the U.S. Environmental Protection Agency for an independent study on the state-of-the-art in risk analysis and assessment. The book provides a useful review of the history of risk assessment, as well as excellent guidance on frameworks for risk assessment that include science-based and value-based information. The book concludes by offering recommendations for improving decisions. Although some details are most suitable to the regulatory context, most of the material in the book has clear relevance to the fire management context. The book builds upon and is considered complementary to an earlier, widely used book:

Committee on the Institutional Means for Assessment of Risks to Public Health, Commission on Life Sciences, and the National Research Council. 1983. Risk assessment in the Federal Government. Washington, DC: National Academy Press. 191 p. [Known as “the Red Book,” not to be confused with the “Redbook,” which documents interagency standards for fire operations.]

Olson, Robert L.; Bengston, David N.; DeVaney, Leif A.; Thompson, Trevor A.C. 2015. Wildland fire management futures: Insights from a foresight panel. Gen. Tech. Rep. NRS-152. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 44 p.

This report helps frame the magnitude of the fire management problem, notably clearly outlining the case that business-as-usual is unsustainable.

Russo, J. Edward; Schoemaker, Paul J.H. 1989. Decision traps: The ten barriers to brilliant decision-making and how to overcome them. New York: Simon & Schuster. 280 p.

Although a concise treatise on barriers to good decisionmaking, this very readable book also provides valuable guidance on how to approach all types of decision problems including those of risk management.

Scott, Joe H.; Thompson, Matthew P.; Calkin, David E. 2013. A wildfire risk assessment framework for land and resource management. Gen. Tech. Rep. RMRS-GTR-315. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 83 p.

This report provides a template of a risk assessment framework that has now been widely adopted by the Forest Service at national, regional, and forest-level planning scales. Even though other tools and approaches exist, and the state-of-the-art is ever-improving, the report is a useful jumping-off point for managers interested in learning about the basic ingredients and steps in performing a landscape risk assessment.

Thompson, Matthew P.; Zimmerman, Tom; Mindar, Dan; Taber, Mary. 2016. Risk terminology primer: Basic principles and a glossary for the wildland fire management community. Gen. Tech. Rep. RMRS-GTR-349. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 13 p.

The objective of this companion report is to help develop a common language and understanding of terms associated with risk, risk assessment, and risk management in the wildland fire context.

Yoe, Charles. 2011. Primer on risk analysis: Decision making under uncertainty. Boca Raton, FL: CRC Press. 251 p.

This is a very readable book that facilitates a strong understanding of the underlying language and concepts of risk. In particular we found great value in the chapters describing risk assessment, risk communication, and risk management options. Although there are some differences between the presentation of risk analysis and risk management in this book and that of ISO, the

differences are clearly laid out and easy to reconcile. Interested readers might also consider a companion volume by the same author:

Yoe, Charles. 2011. Principles of risk analysis: Decision making under uncertainty. Boca Raton, FL: CRC Press. 584 p.

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