USDA Forest Service
U.S. DEPARTMENT OF AGRICULTURE

Rocky Mountain Research Station

Science You Can Use 101

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Wildfire Risk 101

The word “risk” is often used informally to talk about feelings of danger or chances of loss. When communicating about wildfire risk, both inside the Forest Service and with the public and others, careful and intentional use of the term “risk” is more likely to increase shared understanding of all involved.

What does “risk” mean? How is risk measured? How can wildfire risk be reduced? Can wildfire risk be eliminated? Here, we share definitions of risk in a technical sense, consistent with how the insurance industry considers risk. We focus mainly on wildfire risk related to communities, and how that risk can be reduced.

What Is Risk?

Risk is a measure of the probability and consequence of uncertain future events. Taking risk often involves accepting or trying to improve your circumstances, knowing an outcome could be negative. Though not all risks are negative, taking risk can result in positive outcomes. The decisions we make have inherent and complex tradeoffs. Risk is the framework for understanding the implications of decisions.

We commonly consider risk in everyday life. For example, a person decides to commute to work by bike because it will keep them fit and reduce their stress, although there is a slim chance they could get hit by a car. In this situation, the person determines the benefits of biking are likely worth the risk—the consequence of getting hit would be high, but the probability is very low. This person may decide to reduce their risk by either wearing reflective clothing, lights, and a helmet, or choosing a route with little traffic.

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What Is Wildfire Risk?

Wildfire risk is the likelihood of a wildfire occurring and the potential effects it would have on things we care about. The uncertain future is whether a wildfire will occur and how intense it will be if it occurs. Uncertainty is inherent in wildfire. Risk is a way for us to evaluate this uncertainty. By estimating the likelihood and consequences of wildfires, we are better able to consider and plan for possible outcomes.

Wildfire risk is the likelihood of a wildfire occurring and the potential effects it would have on things we care about.

We can think of wildfire risk as a simple equation of "hazard x vulnerability" (see illustration). The first part of the equation, **wildfire hazard**, reflects landscape conditions and consists of two components: wildfire likelihood and intensity.

- **Wildfire likelihood** is the probability that any specific location may experience wildfire in a given year.
- **Wildfire intensity** refers to the amount of energy released from a wildfire. It is largely dependent on the type, arrangement, and amount of fuel (live and dead vegetation) available to burn and is commonly observed and expressed as flame length.

The second part of the equation, **wildfire vulnerability**, reflects the characteristics of the things at risk: exposure and susceptibility.

- **Wildfire exposure** refers to how wildfire hazard overlaps with things we care about such as homes, infrastructure, or specific natural resources (commonly referred to as "values at risk" or "highly valued resources and assets").
- **Susceptibility** refers to the likely effects that fire of different intensities would have on these things, if a wildfire were to occur. Any community that is located where wildfires can occur has some amount of wildfire risk because of the specific combination of wildfire likelihood and intensity on the landscape, and the exposure and susceptibility of resources and assets in and around that community.

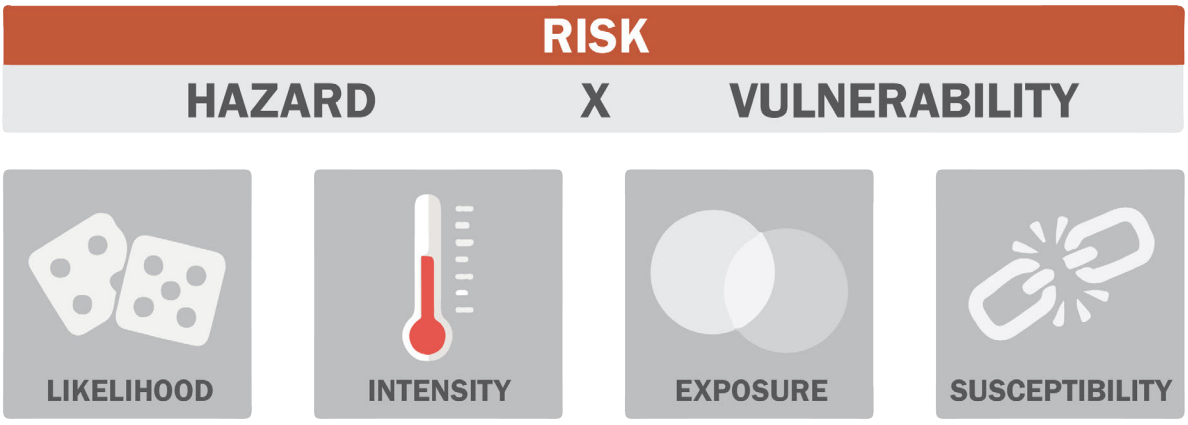

Figure courtesy of wildfirerisk.org

It is important to distinguish that this definition of wildfire risk, focused on potential losses and benefits to resources and assets across a landscape, is different from the personal and organizational risks associated with managing wildfires. Firefighters work in inherently hazardous environments that pose risks to their personal safety. These are referred to as operational risks—the uncertainties and hazards faced by an organization in regular and recurring activities. Understanding the wildfire risks to things of value on the landscape can help when assessing appropriate levels of operational risk, answering questions such as "Why are we taking this action or should we take this action with its associated risks to fire responders?" and "What is our probability of success if we take this action?"

How Is Risk Measured?

The tricky thing about wildfire risk is that it cannot be directly observed in the field. In theory, risk can be inferred from observations of fires and their impacts over many years, but this approach to understanding risk is usually not practical. Instead, modeling can help us more reliably understand wildfire risk and changes to risk. Fire analysts use computer-based fire behavior models to estimate wildfire likelihood and the probability of different fire intensities under various weather scenarios. Observations from the field plus expert input from resource managers and structural fire specialists can help estimate susceptibility. Wildfire analysts can then use these components in a spatial context to quantify risk and evaluate the degree to which changes in likelihood, intensity, and/or susceptibility can change risk. These types of analyses produce information about potential and expected losses and benefits from wildfire that can inform wildfire management decisions.

The analytical framework for measuring landscape-scale risk to specific highly valued resources and assets is called Quantitative Wildfire Risk Assessment (QWRA). QWRA results exist for many regions of the country, and their purpose is to provide baseline information about wildfire hazard and risk across a geographic area. The QWRA process can also be an integral part of fuel treatment planning, providing managers with a quantitative way to compare different treatment alternatives.

The Interagency Fuel Treatment Decision Support System (IFTDSS) is a tool that makes the QWRA process accessible to anyone. It is a free web-based application that includes a QWRA module. Managers can create maps of current risk to resources and assets they specify, and they can use information they generate in the QWRA module to plan fuel treatments, preplan suppression response, design fire effects

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monitoring programs, and inform other related management activities on a landscape, all while accounting for the predicted benefits and threats from fire and the relative importance of different landscape values. Users of the QWRA in IFTDSS can assess differences in pre- and posttreatment risk for multiple treatment scenarios to determine the best alternative for implementation.

What Are the Values or Resources We Can Estimate Risk For?

We can estimate risk to natural resources or human-built assets including communities (homes or buildings), critical infrastructure, water supplies, habitat for specific wildlife species, and ecological conditions more broadly. For assets like homes, risk will always be a negative number, reflecting potential losses from wildfire. For some resources, like fire dependent ecosystems, risk may be negative in some situations and positive in others, reflecting the potential for losses and benefits as a result of fire. Risk can be estimated for an individual type of resource or asset, or to multiple resources or assets at once. Managers and stakeholders can weigh the individual estimates in the context of specific management objectives, while aggregated measures of risk can provide a big-picture perspective.

Can Wildfire Risk Be Reduced?

Wildfire risk can be changed through three types of actions: (1) actions that reduce the intensity of wildfire; (2) actions that decrease the probability of wildfire; and (3) actions that decrease the susceptibility of assets or resources to wildfire effects.

Fuel treatments, sometimes called vegetation management, can change fire intensity and probability by reducing the amount of live and dead vegetation available to burn in a wildfire. These treatments can take the form of mechanical vegetation removal or burning. Probability of wildfire impacts to homes, communities, and other resources can be reduced when large scale fuel treatments or previous wildfires break up the continuity of fuels across a landscape enough to decrease the chance of fire spreading.

Behavioral changes by people living in or visiting fire-prone areas play a large role in changing the probability and susceptibility of community wildfire risk. Probability of fire can be lessened by reducing human-caused ignitions, since most wildfires that affect communities are human-caused and start on private land. This can be accomplished through wildfire prevention education and fire-safe practices like extinguishing campfires immediately or installing spark arresters on equipment.

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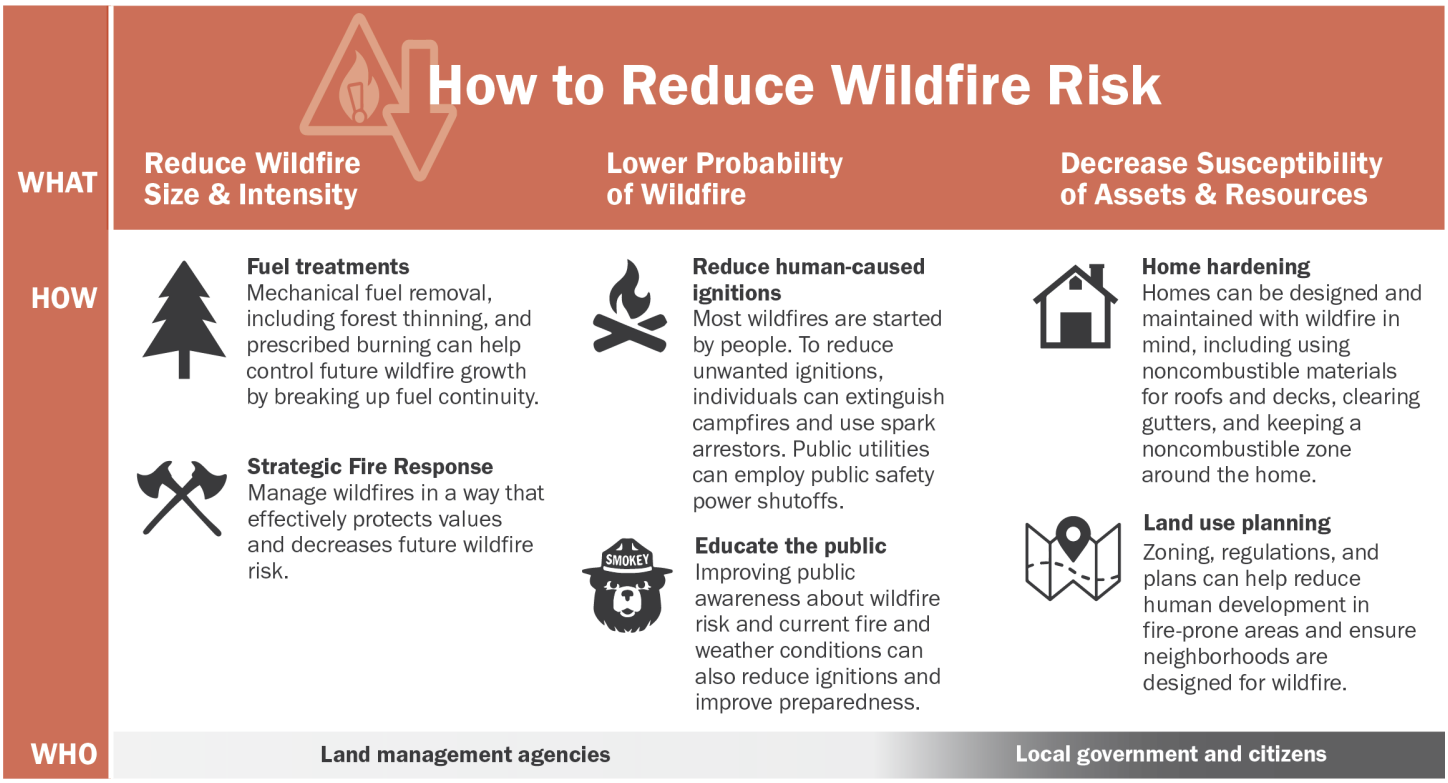

Developed in conjunction with Headwaters Economics

Home susceptibility to wildfire can be reduced by eliminating flammable materials within the home ignition zone (the area immediately surrounding a home, generally 100–200 feet) and home hardening practices (e.g., installing nonflammable roofing material, mounting ember-resistant vents, removing combustible items from decks). These actions substantially change a home's likelihood of being damaged in a wildfire. Additionally, wildfire susceptibility at the community scale can be reduced through land use planning, such as zoning and building codes, that reinforce fire-safe practices.

What Do We Know About Scale and Time Relative to Wildfire Risk Reduction?

When thinking about wildfire risk, it is important to consider spatial scale. As one moves from the small scale of a single house or small neighborhood up to larger scales, like one or more communities or a large watershed, changing wildfire risk increasingly requires coordinated efforts among community leaders, homeowners, public land managers, utilities, and other partners to develop strategic plans that address multiple components of wildfire risk.

Time is also relevant to wildfire risk. The risk reduction benefits from fuel treatments or previously burned areas have limited life spans. In some settings, burn scars from past wildfires are effective at reducing

wildfire risk for many years. In other cases, vegetation and fuel can accumulate quickly. Fuel treatments such as prescribed fire must be repeated at regular intervals to maintain lower risk conditions. Wildfire risk is dynamic throughout the year depending on seasonal weather and fuel conditions. Because of this, it is important to know something about the weather and fuel conditions used to produce maps of wildfire risk and know how those compare with current conditions.

How Can Community Wildfire Risk Be Reduced?

"All of the above" is often the correct answer when it comes to reducing wildfire risk to communities. From individual residents and property owners to public land managers to anyone visiting or recreating on public lands, everyone has a role to play in reducing wildfire risk. Public land management agencies can influence components of wildfire hazard with prescribed burning, managed wildfires, fuel reduction treatments, and other vegetation management activities. In almost all cases, however, this type of risk reduction work on public lands alone is not enough to protect communities from wildfire. Residents and local officials at all jurisdictional levels can reduce their wildfire risk through a wide range of activities. Public education efforts focused on fire prevention and enforcement of fire restrictions can limit unwanted ignitions. Thoughtful land use planning and building codes can focus on home hardening and home ignition zone guidelines that create ignition-resistant homes

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and neighborhoods. And fuel reduction work on private land can be critical to reduce hazard in areas closest to where people live and work. While risk can never be reduced to zero in areas where wildfires and homes co-occur, a coordinated effort from all players can greatly reduce the likelihood of negative wildfire outcomes.

The Wildfire Risk to Communities website, developed by the Forest Service under the direction of Congress, provides a comprehensive community-level view of wildfire risk in the United States. The project evaluates risk to where people live based on wildfire modeling, Census Bureau datasets, and state-of-the-art building footprint data. The website has information and links to resources around different themes of community wildfire risk reduction activities.

How Do We Measure Change in Risk to Communities?

Wildfire risk is dynamic and changes through behaviors and actions of landowners, managers, and policymakers and also through changes in vegetation and weather conditions over time. In the Wildfire Crisis Strategy (WCS), risk to communities generally refers to the built environment and management objectives that are framed around limiting loss to life and property from wildfire events. WCS work is largely focused in firesheds responsible for relatively high amounts of community wildfire exposure communities, areas where fires are most likely to ignite and spread to communities.

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RiskMonitor is an analytical framework that uses Quantitative Wildfire Risk Assessment (QWRA) methods described above to estimate risk at two points in time and evaluate the difference. By comparing estimates of risk to communities before and after proposed treatment activities, managers can better understand where treatments can have the biggest impact on risk. These assessments of change in risk consider areas where people live, critical infrastructure, and source areas for community water supply. Risk analysis does not prescribe what actions should be taken. Instead, it provides insights about where certain actions are more likely to achieve land and fire management goals and be more effective at reducing the potential for negative effects to things we care about. The RiskMonitor framework is being used on WCS landscapes to support both risk-informed strategic plan development and evaluation of risk-based outcome performance.

"If we haven't done work to limit loss to communities in advance, we don't have decision space once a fire is burning to benefit ecological values."

– Tonja Opperman, Intermountain Region Fuels Planner

What Does Preplanning for Wildfire Have to Do With Wildfire Risk?

Preplanning for wildfires is crucial to reducing risk and improving outcomes. Advance planning expands decision-making options available when wildfires do occur. When planning involves partners and communities before fires happen, there is a shared understanding of landscape risks and the best risk management approaches. By considering wildfire risk across all lands and scenarios, discussions can identify local priorities and where taking action will have the most benefit. This approach also allows managers and communities to consider how effective fuel treatments will be in reducing hazard and providing future anchor points for wildfire response. Through preplanning, managers can determine where fuel treatments, community hardening, and other activities will yield the best long-term wildfire outcomes, regardless of land ownership.

One approach to preplanning for wildfire is through the Potential Operational Delineations process, often referred to as PODs. The PODs framework is a proactive planning method in which fire managers and community leaders work together before wildfires occur to identify risks to valued resources and assets and to identify potential opportunities to control wildfires that threaten these resources. In addition to representing a planning framework, PODs refer to spatial units or containers defined by potential control features, such as roads, ridge tops, vegetation treatment units, and past wildfire burn scars within which relevant information on forest conditions, ecology, and fire potential can be summarized.

Key Wildfire Risk Definitions

Decision space refers to the decision options available under a given set of conditions; it widens when planning for wildfire is done in advance.

Expected net value change (eNVC) describes the net expected change in the value of a resource or asset following fire, factoring in potential damaging and beneficial fire effects. It is expected because it incorporates probabilities of fire occurrence and intensity. In the case of built assets, where fire effects are always considered damaging, it can be thought of as simply expected losses.

Home hardening refers to the use of noncombustible materials (e.g., nonflammable roofing material, ember-resistant vents) in home construction, and other preventative practices (e.g., removing combustible items from around homes) that make home structures and properties more resistant to ignition during a wildfire.

Home ignition zone (HIZ) is the area immediately surrounding a home, generally within 100 feet. The HIZ has three sub-zones: the immediate 0-to-5-foot noncombustible zone, the intermediate 5-to-30-foot landscaping/hardscaping zone, and the 30-to-100-foot extended landscaping zone.

Operational risk refers to the uncertainties and hazards faced by an organization or individual in regular and recurring activities. It considers the risks to fire responders in engaging in fire management activities.

Risk is a measure of the probability and consequence of uncertain future events; the framework for understanding the implications of decisions.

Susceptibility is an estimate of the likely effect that wildfire would have on a specific resource or asset at different fire intensity levels.

Wildfire exposure refers to the spatial overlap of hazard with things we care about such as homes, infrastructure, or specific natural resources.

Wildfire hazard refers to the physical condition presented by the combination of fuel, weather, topography, and ignition potential that creates potential for damaging wildfire. It is often quantified as the combination of probability of fire occurrence and the conditional intensity if fire occurs.

Wildfire intensity refers to the amount of energy expected from a wildfire. It is largely dependent on the type and amount of fuel (live and dead vegetation) available to burn and is commonly observed and expressed as flame length.

Wildfire probability is the chance of a wildfire burning in a specific location, typically in a given year (i.e., annual probability).

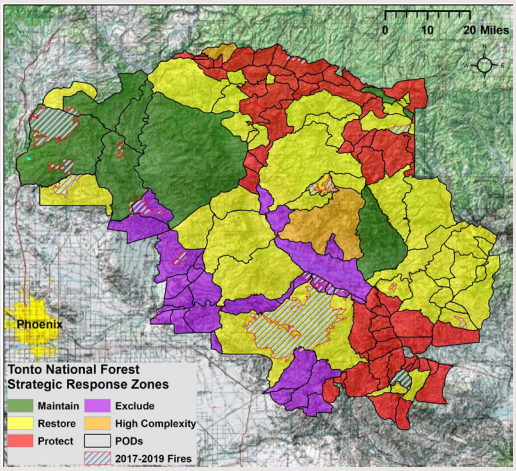
Wildfire risk is a measure of the likelihood of a wildfire occurring at a given intensity and the potential effects it would have on something we care about. It reflects the potential realization of wildfire consequences to something of value.

Wildfire Risk Science-Based Frameworks Products and Tools

Firesheds are a network of systematically generated polygons across the United States used to summarize wildfire statistics. The Fireshed Registry is a geospatial dashboard for land managers and decisionmakers to view and map a vast array of data related to wildfire transmission, past, present, and future management, and past and simulated wildfires. The Fireshed Registry is the data backbone for the Scenario Investment Planning Platform, which simulates specific investment scenarios and resulting possible outcomes for reducing wildfire transmission to communities.

Incident Strategic Alignment Process (ISAP) is a framework for informed risk-based decision making throughout the duration of an incident. ISAP is a consistent process intended to help assess, understand, and communicate risk associated with fire management strategies. ISAP is founded on four pillars: (1) critical values at risk; (2) strategy and strategic actions; (3) risks to responders; and (4) probability of success. ISAP is the product of the interagency fire management community. ISAP integrates research tools from RMRS including Potential Control Locations (PCL), Suppression Difficulty Index (SDI), and Snag Hazard Mapping to facilitate meaningful dialogue and foster alignment, focus efforts, and help prioritize work.

Interagency Fuel Treatment Decision Support System (IFTDSS) incorporated as part of the planning cycle is a Quantitative Wildfire Risk Assessment (QWRA) process. The planning cycle/QWRA process includes landscape creation and/or editing, modeling landscape burn probability, defining and evaluating highly valued resources or assets (HVRAs) and the end point of running a QWRA to evaluate the net threat or benefit of fire on a given landscape. The key aspect of the IFTDSS QWRA is that it is more locally based and a "living" Risk Assessment in that the data and information can be run time and time again in IFTDSS as actions are taken on the landscape of interest to see how the assessment of risk changes. Other efforts produce a map or outline elements (some being national) that are static and require other resources beyond local users with access to an application like IFTDSS to be able to provide updated risk assessment information. IFTDSS is designed to support users in comparing QWRA outputs and assessing the impacts of treatment alternatives.



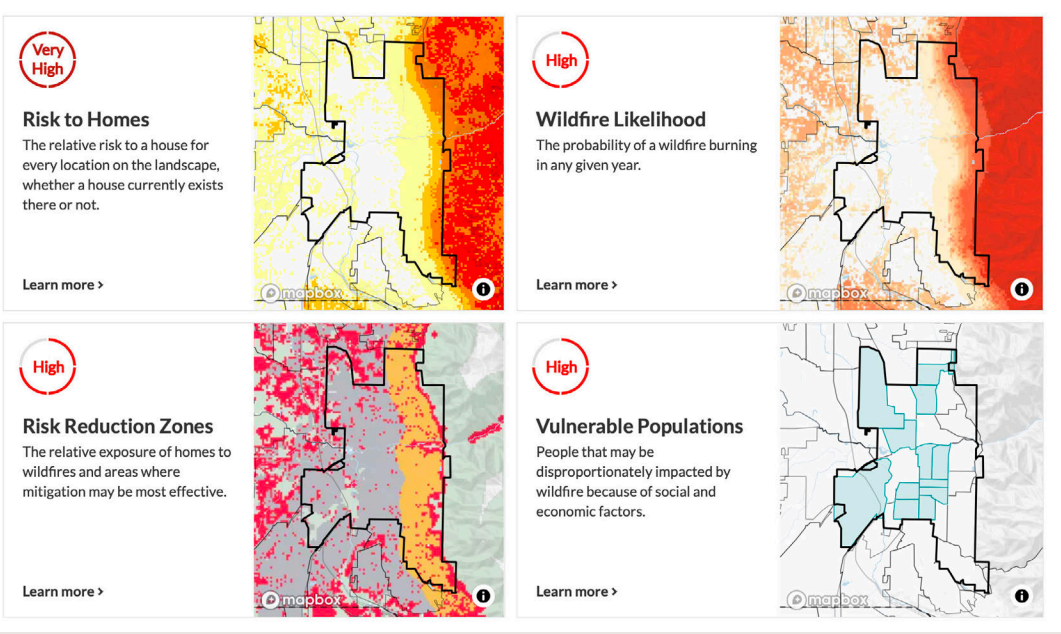
Potential Operational Delineations (PODs): The Rocky Mountain Research Station Wildfire Risk Management Science (WRMS) Team co-developed Potential Operational Delineations (PODs) to preplan for fire using a risk management approach, and to give land managers a formal process for developing landscape-scale wildfire response options before fires start. PODs are spatial units or containers defined by potential control features, such as roads and ridge tops, within which relevant information on forest conditions, ecology, and fire potential can be summarized. PODs combine local fire knowledge with advanced spatial analytics to help managers develop a common understanding of risks, management opportunities, and desired outcomes to determine fire management objectives.

Risk Management Assistance (RMA) is a USDA Forest Service program that helps improve the quality of strategic decisions during the largest and most complex wildfire events. The program was introduced in 2016 and includes tools to help line officers, fire managers, and other groups make risk-informed decisions. The RMA Dashboard presents a series of products, such as the Snag Hazard Map and the Fire Comparison Spreadsheet, that help respondents visualize and prioritize scarce resources based on need.

RiskMonitor is an analytical framework that helps managers identify the most effective treatment strategies to reduce wildfire risk to communities and infrastructure and monitor progress toward risk reduction goals. The RiskMonitor framework was developed by RMRS analysts at the Fire Modeling Institute and is being used on Wildfire Crisis Strategy (WCS) landscapes to support risk-informed strategic plan development. In the project planning context, it provides insights about the most effective strategies across different parts of a landscape based on the potential of treatments to change expected fire behavior. In the context of outcome performance measures, RiskMonitor provides the analytical building blocks needed to evaluate and monitor specific changes in risk and exposure over time.

Quantitative Wildfire Risk Assessments (QWRA) provide a method by which we can calculate risk based on measurements or estimates of various risk components such as likelihood of fire occurrence, intensity of fire should it occur, and susceptibility to fire of the various highly valued resources and assets.

The Wildfire Risk to Communities website is a one-stop resource where citizens and community leaders can assess the wildfire risk of their area and find resources to reduce the risk. WRC was developed by the Forest Service, at the behest of Congress, and the technical analysis for this product was led by a Rocky Mountain Research Station team. By providing nationwide coverage of wildfire risk, it is possible to compare wildfire risk among states, tribal areas, counties, or communities. Local officials and community leaders can learn about effective strategies to mitigate their community's risk. The website has information and links to resources related to 10 different themes of community wildfire risk reduction activities: ignition-resistant homes, land use planning, evacuation and readiness, smoke ready, prevent ignitions, response, equitable risk reduction, hazardous fuels management, recovery and rebuilding, and funding.



Learn More About Risk

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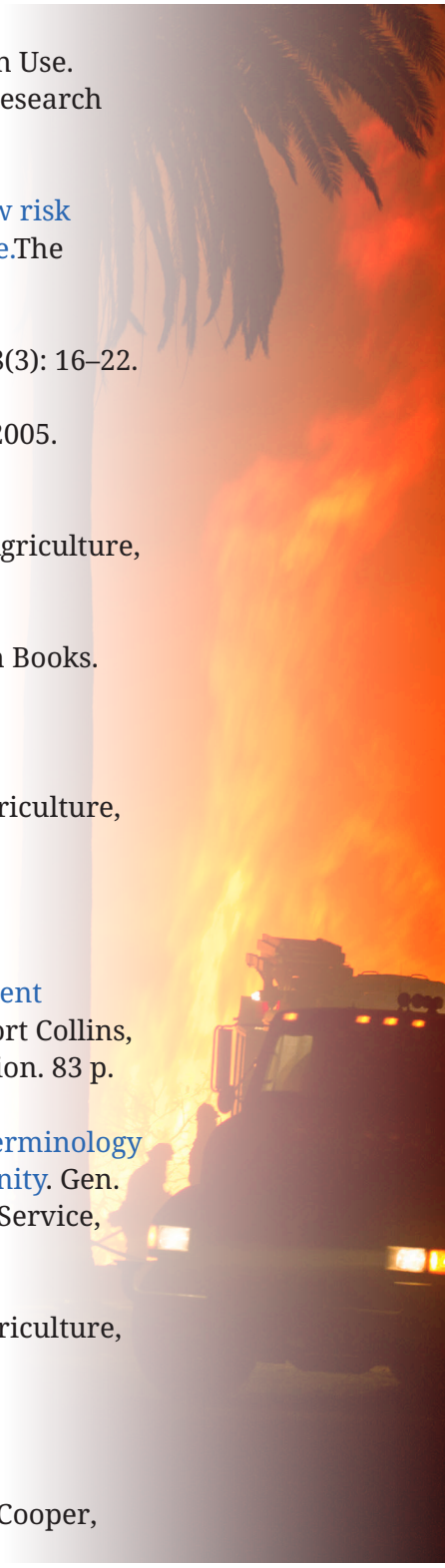

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