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Rocky Mountain Research Station 2008–2012 National Fire Plan Investments

A summary of selected scientific research in the five core areas of the Wildland Fire and Fuels Research and Development Strategic Plan

Investing in Today's Science to Sustain Tomorrow's Natural Resources

Abstract

This report highlights selected accomplishments by the USDA Forest Service Rocky Mountain Research Station's Wildland Fire and Fuels Research & Development projects in support of the National Fire Plan from 2008 through 2012. These projects are examples of the broad range of knowledge and tools developed by National Fire Plan funding beginning in 2008.

Editor

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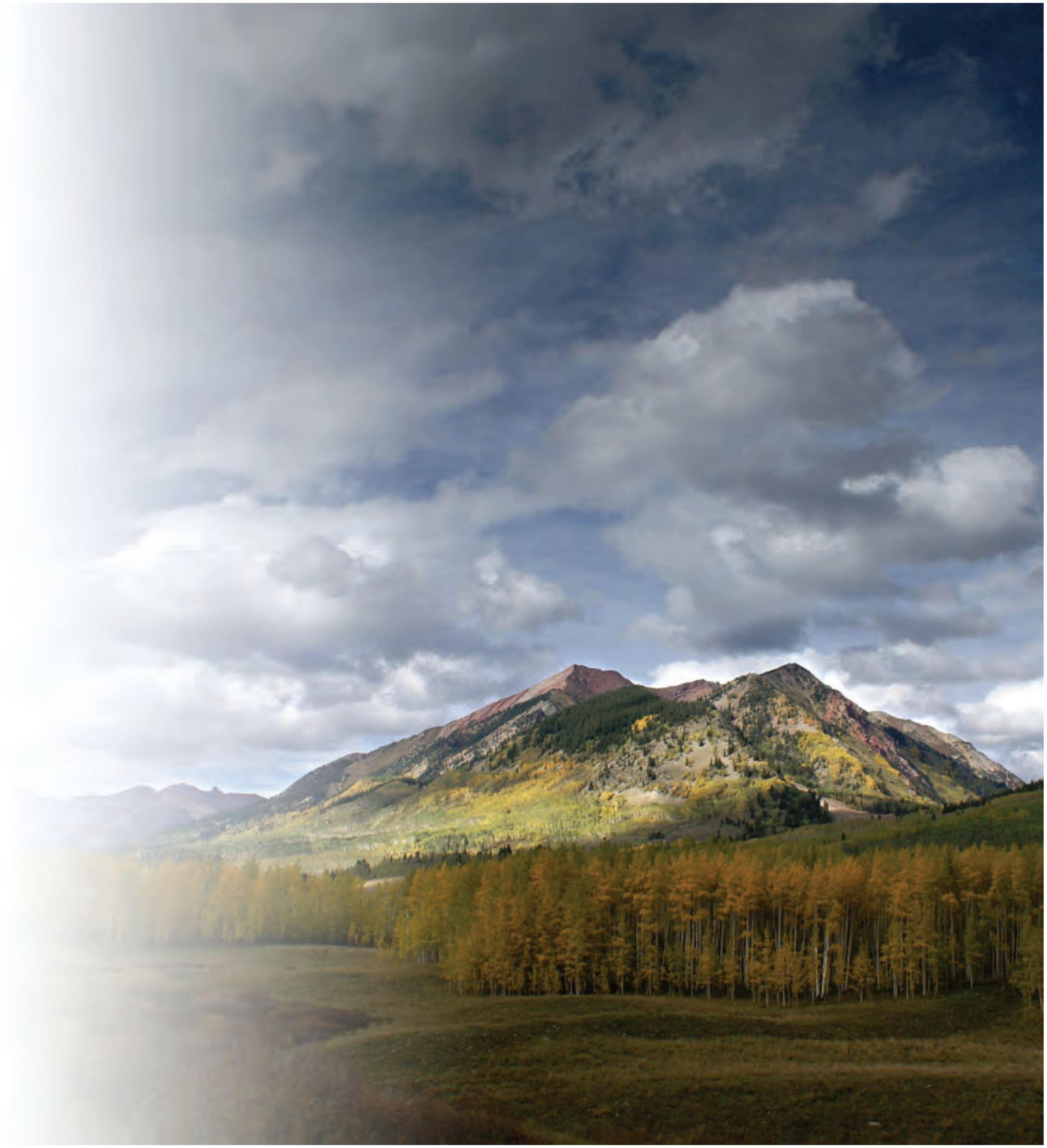

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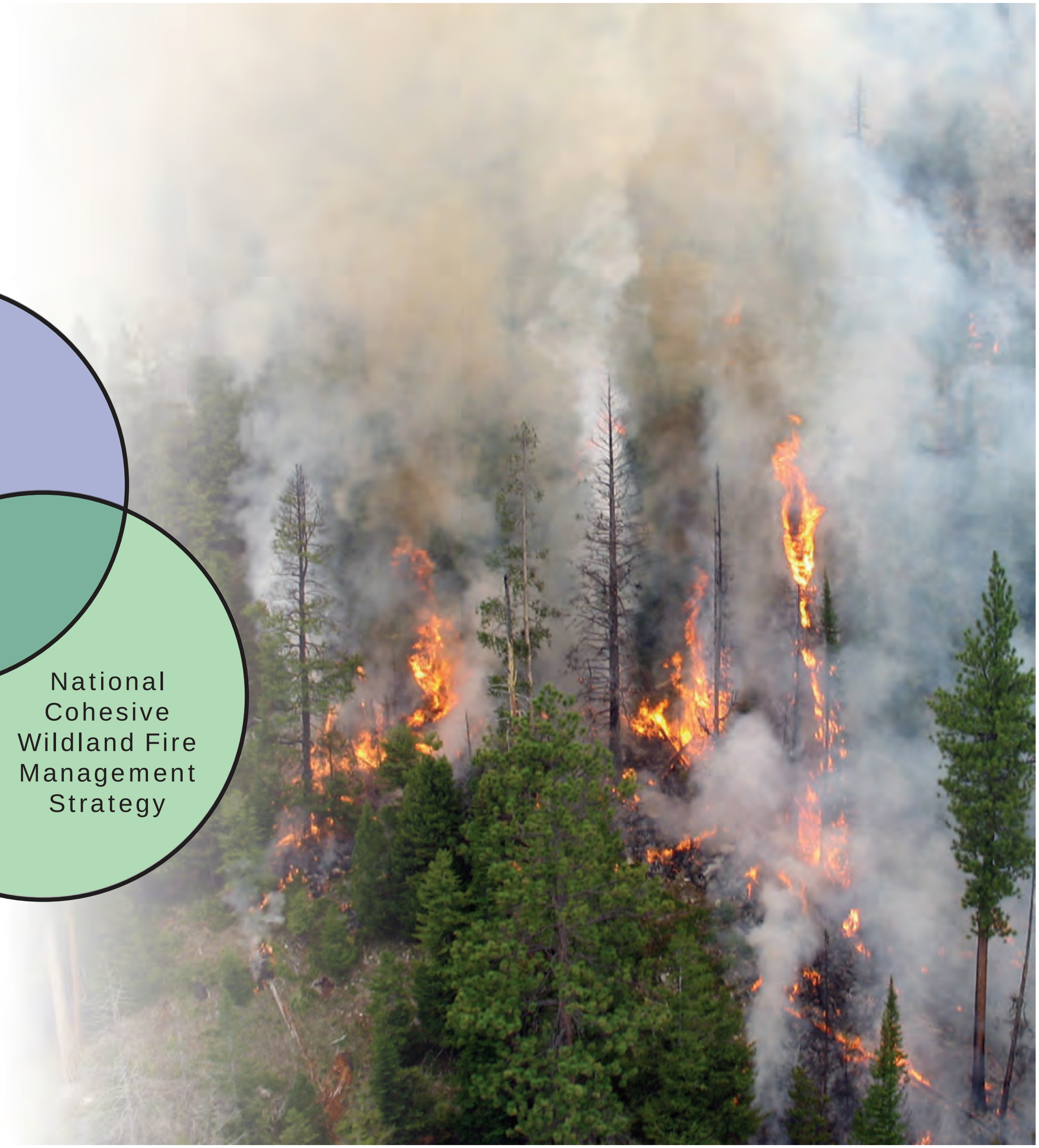


About the National Fire Plan

Fire is a natural phenomenon that occurs throughout the course of nature. Many plant and animal species and communities are dependent on natural fire regimes to regenerate and persist over time. Yet in the past decades, spread of invasive plant species, increasing mountain pine beetle outbreaks, increasing forest fuel densities, and changing climates have directly affected the severity and frequency of wildland fires. These dynamic trends pose a threat to many natural ecosystems in the Interior West and adversely affect our nation's precious and vital natural resources. These trends also significantly increase social, economic, and environmental costs associated with fire suppression, land management, ecosystem restoration, and community assistance.

Background: From the National Fire Plan to the Wildland Fire and Fuels Research & Development Strategic Plan

Since the establishment of the interagency National Fire Plan in 2001, various goals and approaches have been adopted as keystone strategies in the evolution of the National Fire Plan. The Four key focus areas in the original National Fire Plan were: *firefighting capacity, rehabilitation and restoration, hazardous fuels reduction, and community assistance*, as identified by the fire and fuels management communities in, "Managing the Impact of Wildfires on Communities and the Environment" (USDA and DOI 2000) and "A Collaborative Approach for Reducing Wildland Fire Risk to Communities and the Environment: 10 Year Comprehensive Strategy" (USDA and DOI 2002).

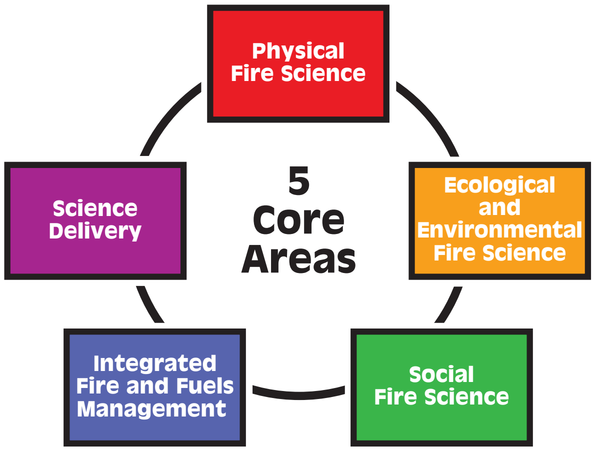
Since then, many subsequent strategic amalgamations have integrated previous focus areas, goals, and frameworks, and resulted in the USDA Forest Service's "Wildland Fire and Fuels Research and Development Strategic Plan: Meeting the Needs of the Future" (USDA Forest Service 2006). This publication provides the requisite criteria used by the Rocky Mountain Research Station to fund all National Fire Plan research projects.

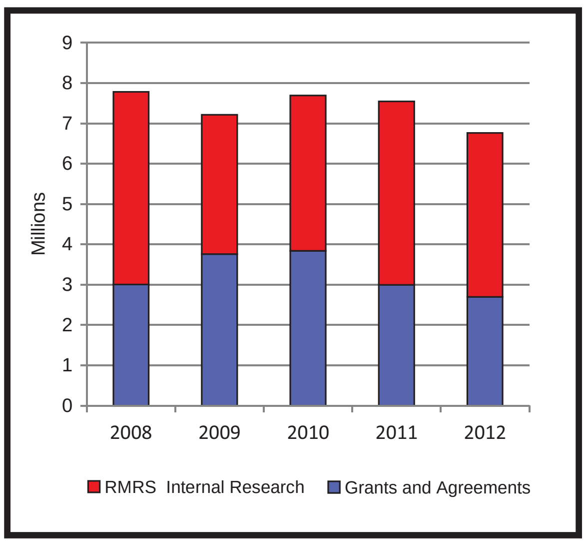
By providing science based information and tools in the context of changing fire regimes, climate, environment, land use, and social needs and priorities, the five core research areas of the Wildland Fire and Fuels Research & Development Strategic Plan provide the science needed to support the three Goals of the National Cohesive Wildland Fire Management Strategy, and assist federal, state, tribal and local agencies and communities with fire mitigation efforts.

Three Goals of the National Cohesive Wildland Fire Management Strategy:

- **Restore and Maintain Resilient Landscapes:** landscapes across all jurisdictions are resilient to fire-related disturbances in accordance with management objectives.
- **Fire Adapted Communities:** human populations and infrastructure can withstand a wildfire without loss of life and property.
- **Wildfire Response:** all jurisdictions participate in making and implementing safe, effective, efficient risk-based wildfire management decisions.

The Five Core Areas of the Wildland Fire and Fuels Research & Development Strategic Plan





National Fire Plan funds received by RMRS. Shows proportion of grants and agreements for collaborative research given to partner research organizations

Physical Fire Science:

Core fire science, including physical fire processes, the characteristics of fire at multiple scales, and fire danger assessment.

Ecological and Environmental Fire Science:

Fire effects on ecosystem components, and fire and environmental interactions.

Social Fire Science:

Public interactions with fire and fuels management, socio-economic aspects of fire and fuels management, and organizational effectiveness.

Integrated Fire and Fuels Management:

Management strategies at multiple scales, treatment and components, and forest operations, including biomass utilization and product development associated with fire and fuel management activities.

Science Delivery:

Core fire science, including physical fire processes, the characteristics of fire at multiple scales, and fire danger assessment.

RMRS Selected Research Projects in Support of the Wildland Fire and Fuels Research & Development Strategic Plan

Physical Fire Science

- Developing Smoke Transport Models with Airborne Experiments.
- Improving LIDAR Technology through Innovation.
- Fire Activity in Northern Eurasia 2002-2010.
- Firefighter Safety Zones—Revising Safety Zone Guidelines.
- Energy Transport in Wildland Fires—Developing a New Understanding.
- HIGRAD/FIRETEC—A High-tech Tool for Simulating the Effect of Bark Beetle Outbreaks on Fire Behavior.

Ecological and Environmental Fire Science

- Fire and Fuel in the Bosques of New Mexico.
- Birds and Fire.
- Factors Affecting Resilience to Disturbance and Resistance to Invasive Plants in the Great Basin.
- Climate Change and Wildfire Effects on Stream Temperatures & Thermal Habitat.

Social Fire Science

- Perspectives on Risk in the Wildland-urban interface.
- Community Capacity, Social Diversity, and Adapting to Wildfire Risk in the Wildland-urban interface.
- The Wildland-urban interface & Risks to Natural Fire Regimes.
- Mapping Current & Potential Biomass Flows from National Forest Treatments.

Integrated Fire and Fuels Management

- Fuel Management and the Post-Fire Environment.
- Spatial Variability of Wildland Fuel.
- Index for Characterizing Post-Fire Soil Environments in Temperate Coniferous Forests.

Science Delivery

- Adapting the Watershed Erosion Prediction Project Model to the Burned Area Emergency Response Protocol.
- OptFuels: Fuel Treatment Optimization.
- A Comprehensive Guide to Fuels Management Practices for Dry Mixed Conifer Forests in the Northwestern United States.
- Wildland Fire Management RD&A Program.
- Human Factors and Risk Management RD&A Program.

"In a dynamic resource environment it is essential that resource and land management tools are based on the most accurate science, and technology is made available to support land managers, fire managers, key stakeholders, and the public at-large in ways they want to receive it."

— G. Sam Foster, RMRS Station Director

Developing Smoke Transport Models with Airborne Experiments

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Wildland fires are a significant source of airborne pollutants. Air quality regulators and land managers employ smoke modeling systems to predict, evaluate, and manage the impacts of fire emissions on air quality. While much progress has recently been achieved in understanding the smoke chemistry of prescribed burning, significant knowledge gaps in the chemistry of wildfire smoke have hindered the development of reliable smoke modeling systems.

The RMRS Smoke Emission and Dispersion Research Team conducted a multi-year smoke chemistry field research project to characterize emissions from western U.S. wildfires. The project, co-funded by the Joint Fire Sciences Program, and USDA Forest Service Research & Development, installed smoke chemistry measurement instruments on a USDA Forest Service Cessna aircraft. Using the Cessna as a platform, fresh emissions and smoke dispersion were measured from 25 wildfires in the western U.S.

The measurements found that wildfires in the interior mountain west burned with much lower combustion efficiency than prescribed fires. Thus, for a given mass of vegetation burned, wildfires emit more fine particulate matter and more non-methane organic compounds. This leads to increased levels of ground-level ozone, which can negatively impact human health as well as wildlife and terrestrial ecosystems.

These results indicate that previous estimates of wildfire emissions underestimated the production of these pollutants and the potential of wildfires to degrade local and regional air quality. This research will enhance the ability of land managers and air quality regulators to mitigate the effects of wildland fires on human health, economic activity, and aesthetic integrity.

For more information on smoke emissions projects, visit www.firelab.org/research-projects/smoke-emissions.

Schulz Fire, Arizona 2010

Improving LIDAR Technology through Innovation

LIDAR equipment in the field

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LIDAR (Light Detection and Ranging) technology operates on the same principle as RADAR, transmitting a short electromagnetic pulse and timing the return of the backscattered signal. While RADAR measures the distance between two points in space, atmospheric LIDAR uses a laser beam to determine atmospheric properties. LIDAR can provide a three-dimensional image of the optical characteristics of the searched atmosphere, which enables scientists' better understanding of global processes in the atmosphere.

The LIDAR technology, used extensively by atmospheric and meteorological researchers, is the ideal tool for monitoring the distribution of airborne pollutants caused by wildfires, as well as their dispersion, trajectories, and maximum heights. To investigate smoke plumes originated by wildfires, LIDAR generally utilizes an airborne platform; the laser is mounted on an airplane and emits light pulses down into the smoke-polluted atmosphere. This method, besides being very expensive, does not allow thorough investigation of the smoke-pollution levels near the ground or continuous monitoring of the smoke plume evolution in the vicinity of wildfires.

RMRS scientists from the Missoula Fire Sciences Laboratory have developed innovative and cost-effective solutions to these problems. They have developed a truck-mounted LIDAR scanning system designed specifically for operating in smoke-polluted atmospheres. The system can automatically and rapidly change directions to scan 180 degrees horizontally and 90 degrees vertically. The truck-mounted LIDAR can be quickly mobilized and setup on an incident. It can be programmed to scan in any direction, providing critical real-time and continuous (short or long-term) monitoring while operating from a safety zone outside the burn area, guaranteeing the safety of personnel at costs that are significantly less than other remote sensing methods.

For more information, visit www.firelab.org/facilities-a-resources/99-lidar or www.firescience.gov/projects/briefs/04-1-1-04_FSBrief103.pdf

LIDAR vehicle in the field

Fire Activity in Northern Eurasia 2002-2010

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Northern Eurasia covers 20% of the global landmass, and contains 70% of the boreal forest, the largest terrestrial biome on the planet. Some scientists believe biomass burning in this region may be a significant source of atmospheric black carbon that could accumulate on Arctic ice and accelerate melting.

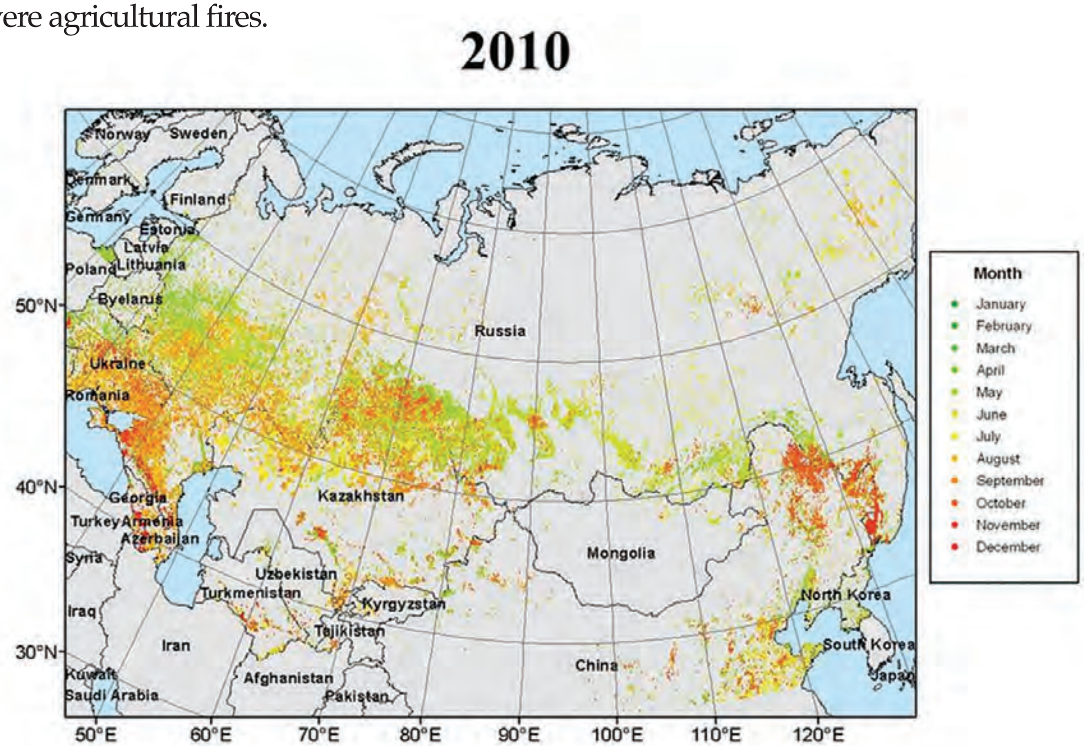
Using data from the Moderate-Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra and Aquatic satellites from 2002 to 2010, RMRS scientists examined daily fire occurrences at a 1 km x 1 km resolution in different land cover categories such as agricultural, grassland, shrubland, and forests. Their results found that during this nine-year period, there was no significant trend in fire occurrences in Northern Eurasia, or within each geographic region, or by land type.

Agricultural residues are often burned after harvest in the fall or before plowing in the spring; therefore, agricultural fires dominated biomass burning in Northern Eurasia, accounting for approximately 52% of satellite fire detections, followed by grassland, forest, and shrubland fires.

In Russia, agricultural fires accounted for approximately 50% of all active fire detections, while approximately 25% of fire detections were forest fires. In Eastern Europe, almost all fires were agricultural fires. In Central and Western Asia, more than 50% of fire detections were grassland fires, and more than 30% were agricultural fires.

This research is critical in understanding the effects of climate change on fire regimes, dynamics, and emissions in Northern Eurasia, which in-turn can impact Arctic ice melting and affect global ecosystems.

For more information about remote sensing research projects, visit www.firelab.org/research-projects/smoke-emissions/120-remote-sensing or modis.gsfc.nasa.gov/about/



Source: NASA MODIS-detected Active Fires in Northern Eurasia in 2010. RMRS Fire, Fuel, and Smoke Science Program-Wei Min Hao, Alex Petkov, Bryce Nordgren, and Rachel Corley

Firefighter Safety Zones—Revising Safety Zone Guidelines

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All wildland firefighters in the U.S. are required to identify safety zones when working on or near fire. The U.S. Forest Service defines this zone as, "a preplanned area of sufficient size and suitable location that is expected to protect fire personnel from known hazards without using fire shelters." Yet quantitative information about the attributes that define a safety zone are limited.

Previous research surveying 330 firefighters found that some firefighters' perceived minimum safety zone distances were greatly skewed. When asked to predict separation distance from flames, their estimations varied by three orders of magnitude. Or when shown pictures of the stated burn conditions, 51% increased the required safety distance in their estimates, while 8% decreased their assessments (Steele 2000).

These findings revealed the difficulties faced by firefighters in visualizing representative fire behavior given weather and topographical conditions in estimating safe separation distances. Additionally, past safety zone studies only used flame height, length, width, burning index, and ratios to assess the distribution of the energy ahead of and around a fire to define heat transfer relationships.

In order to mitigate the inherent hazards of wildland firefighting like injuries and fatalities, RMRS scientists are studying and revising current safety protocols. With co-funding from the Joint Fire Science Program, RMRS scientists have deployed sensors specifically designed to measure temperatures and energy release from fires on more than 50 prescribed and wildland fires. They have completed more than 800 computer simulations of energy transport from fires using state-of-the-art computer models, and reviewed and synthesized pertinent safety zone research and data published from 1973 to 2011.

The intention of this research is to provide firefighters with improved information on the attributes of a safety zone as a function of fire behavior, vegetation, and environment. It is imperative for regulatory agencies to adopt these new guidelines in a timely manner to safeguard our firefighting personnel risking their lives on the fire lines.

For more information, visit to www.firelab.org/research-projects/fire-fuel/125-safety-zones.

Fire crews suppressing Commissary Ridge Fire, Wyoming 2002. Photo by Kelly Close

Energy Transport in Wildland Fires—Developing a New Understanding

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In order to understand and accurately predict the behavior of wildland fires, model fire emissions and energy release, and improve public and wildland firefighter safety, it is necessary to understand how energy is released from wildland fires. RMRS scientists and collaborators from Brigham Young University, Eglin Air Force Base, Joseph W. Jones Ecological Research Center, Joint Fire Sciences Program, Alaska Fire Service, BLM, and the USDA Forest Service Pacific Northwest Research Station have partnered in an ongoing field-based research effort directed at measuring how energy is produced and transported in wildland fires.

Radiative heat transfer (from one surface to another) and convective heat transfer (by movement of gases) play complementary roles in wildland fire spread. While previous studies reported measurements of energy transport from biomass-fueled flames, their scope was limited and primarily focused on radiative energy transport. Therefore, an improved understanding of how energy is transported through both radiative and convective modes in wildland fires remains a critical yet poorly documented element of wildland fire science, and extreme conditions of wildland fires greatly limit measurement methods.

Results indicate that integrated energy release correlated well with fire type for fire radiative energy, but not as clearly for fire convective energy. Scientists are working on formulating a more comprehensive understanding into the complex and dynamic relationship between these synergistic variables. Results from this study will be used to redesign wildland fuel inventory, monitoring, and mapping programs to account for spatial variability in sampling methods.

Fire-behavior packages mounted on tripods gathers data for energy transport modeling as a wildland fire burns around them

HIGRAD/FIRETEC—a High-tech Tool for Simulating the Effect of Bark Beetle Outbreaks on Fire Behavior

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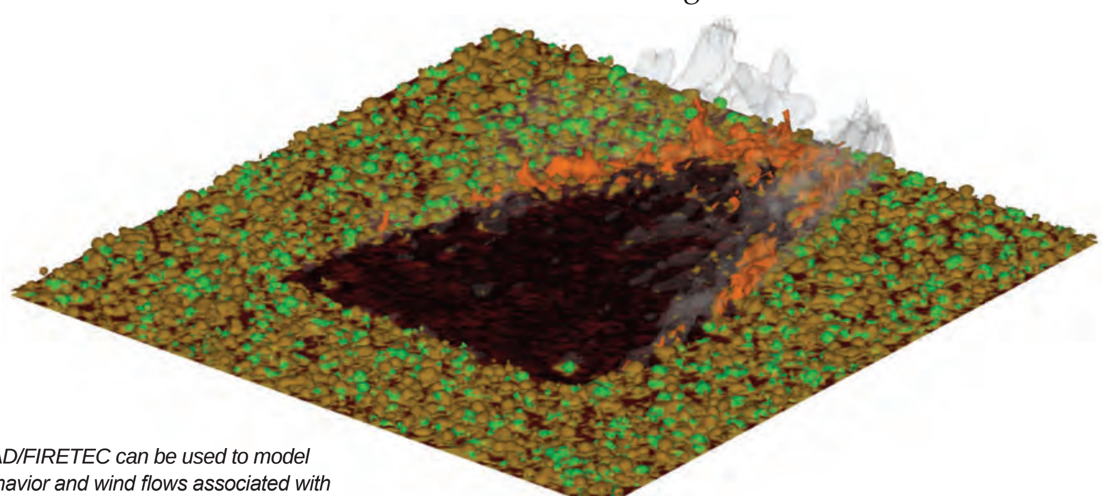
Bark beetle outbreaks can impact the ecology of forest and woodland ecosystems. Tree mortality from bark beetle outbreaks can vary according to beetle type, tree species, forest health, and rate of attack or colonization. Outbreaks can lead to increased tree mortality, which transforms stand structure, variability, and biodiversity. Consequently, these altered structures affect wind flow patterns as well as fuel distribution and moisture content.

Currently, most traditional fire behavior models are programed to operate under average or homogenous moisture conditions, and do not address highly variable conditions like fluctuating wind flow, effects of tree mortality, fuel location and variability (live vs. dead fuels), or ignition thresholds of beetle-killed structures.

In response to these critical issues, RMRS scientists along with scientists from Los Alamos National Laboratory (LANL) led a joint effort to employ a high-tech tool, HIGRAD/FIRETEC, to predict fire behavior in bark beetle-impacted forests. This physics-based three-dimensional computer code was developed to capture fire behavior under variable conditions and simulate the dynamic interactions occurring both within a fire and its external environment. By combining physics based models that represent combustion, heat transfer, aerodynamic drag, and turbulence with terrain, airflow, and variable fuel conditions, this cutting-edge technology will help firefighters anticipate erratic fire behavior and greatly improve overall firefighter and public safety.

For more information about HIGRAD/FIRETEC research, visit www.fs.fed.us/rm/forest-woodland/higrad-firetec/



HIGRAD/FIRETEC can be used to model fire behavior and wind flows associated with highly variable fuels following bark beetle outbreaks

Bark beetle impacted forest in the wildland-urban interface

Fire and Fuel in the Bosques of New Mexico

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As early as the late 1800s, flood control, irrigation, and water supply projects altered many rivers' natural flow, putting an end to natural flood events, high flow monsoons, and spring snowmelt seasons. In response to stream flow regulation, invasive species, drought, and wildfire, riparian forests in the southwestern U.S. have changed dramatically over the past several decades. Currently, many riparian forests have accumulated dead wood on forest floors, invasive species dominating forest cover, and in some cases, diminished water tables. These conditions form dense shrub thickets and provide continuous fuels for wildfire. Scientists believe that under a changing climate with increasing temperatures, heat waves, and severity of drought periods, these conditions will intensify and lead to increased wildfire frequency.

RMRS scientists along with partners from other federal, state, and local organizations examined how management can influence the changing "bosque" and mitigate threats to native species along the Rio Grande. Researchers studied native species responses to wild fire, fuel reduction treatments, and exotic invasive plant removal to aid in determining best fire and fuel management practices. These treatments included complete and partial removal of dead wood and invasive trees and shrubs, followed by direct herbicide application to invasives after cutting, prescribed fire, and replanting with native vegetation.

The study found that some invasive trees re-sprouted to a lesser degree in areas where fuel reduction took place than on areas that had remained untreated or had experienced wildfire. In areas where crews replanted native species, the majority of individual plants survived. However, invasive shrubs seemed to persist on burned sites through dry periods, whereas native trees and shrubs were highly susceptible to drought caused death in the first year after a fire. Therefore, if hydrologic conditions are not ideal, native plants, even when resprouted, may not survive the post-fire period. Invasive species may increase, while native species decrease.

Ultimately, the highest success rates for native species came with replanting both understory and over story vegetation for restoration. This research is vital to better understand and reduce uncharacteristic fire risk via control and eradication of invasive plants and fuels.

For more information on invasive species and restoration, visit www.fs.fed.us/rm/grassland-shrubland-desert/research/focal-areas/

Cleared and chipped bosque

Treated bosque

New burn, post-fire treated bosque resulting in reduced fire damage

Birds and Fire

Forest fire

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In the wake of fires and bark beetle outbreaks, public land managers are responsible for both minimizing fuel levels by using techniques such as salvage logging and maintaining suitable wildlife habitat for species of concern to state and federal agencies. These parallel responsibilities often conflict with one another because forested areas impacted by beetle outbreaks and wildfires that are selected for salvage logging are both preferred habitats for certain wildlife species such as woodpeckers. While minimal information exists on how to assess potential effects of post-fire and post-beetle logging on wildlife populations and habitats, public land managers need consistent design and assessment criteria to maintain suitable habitats. These concerns have led to controversy, conflict, and litigation.

In an effort to assist land managers with forest restoration options, fire and fuels management, and wildlife habitat creation and maintenance, RMRS scientists have studied the effects of fire on birds in dry coniferous forests since the mid 1990s. Although birds' responses to fire vary, most bird species of the Inland West depend on structural characteristics created by fire. Such fire-created habitat conditions largely determine roosting, nesting, and foraging habitat suitability for birds of western forests.

Through the use of remote sensing tools and locally based models, scientists are developing tools to evaluate habitat suitability after wildfire and beetle outbreaks for several species of nesting woodpeckers in the Inland Northwest. Researchers are developing habitat suitability models using burn severity, indices of beetle abundance, and other remotely sensed variables with the Monitoring Trends in Burn Severity (MTBS) and Aerial Detection Survey (ADS) databases, which consist of more than 200 recent wildfires and beetle outbreaks. Maps are developed from these models to provide guidance on which areas can support preferred nesting habitats for black-backed, American three-toed, Lewis's, and white-headed woodpeckers, and which areas can ideally support salvage logging with minimal impact on woodpecker populations.

With warming climates influencing larger and more severe wildfires and beetle outbreaks, and salvage logging practices likely to increase, researchers plan to validate and apply these habitat suitability models across a four state area in the Inland Northwest. The application of these models will ultimately provide accurate and consistent information about post-fire and post-beetle effects for sensitive bird species on 25 national forests.

For more information, visit www.rmrs.nau.edu/wildlife/birdsandburns/

Black-backed Woodpecker

White-headed Woodpecker

Factors Affecting Resilience to Disturbance and Resistance to Invasive Plants in the Great Basin

Color shaded relief map of the Great Basin. Source: RMRS Boise Aquatic Sciences Lab

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In the Great Basin of the western United States, invasion of non-native annual grasses into salt desert and low-to-mid elevation sagebrush ecosystems is increasing fine fuels and resulting in larger and more frequent fires. Likewise, the expansion and infilling of pinyon and juniper trees into mid-to-upper elevation sagebrush ecosystems is resulting in higher fuel loads and increasing the risk of more frequent, larger and higher severity fires. These processes are causing the loss of native shrubland species and leading to widespread ecological degradation. Consequences include an increased risk to human life and property, high fire management costs, loss of economic and natural resources, and more complicated management interventions.

Management objectives for these ecosystems include increasing resilience of native ecosystems to disturbance and/or enhancing resistance to invasion. RMRS scientists along with collaborators from the University of Nevada, Reno, Brigham Young University, and Agricultural Research Service, collected and synthesized data to determine how the resilience and resistance of shrubland ecosystems exhibiting tree expansion and cheatgrass invasion differed across the landscape.

Results showed that resilience to disturbances were primarily a function of *site productivity* – as determined by topography, soils and effective precipitation, and *ecological conditions* – as influenced by tree cover and fire-tolerant herbaceous and shrub species. In contrast, resistance to cheatgrass was largely determined by factors that affect its distribution such as precipitation at lower elevations, soil temperature at higher elevations, and the relative abundance of perennial herbaceous species and grasses which influence competitive ability. This research provides the necessary rationale and framework for prioritizing restoration sites and determining the most effective treatments in both pre- and post-fire environments.

(a) Prescribed fire conducted to increase ecosystem resilience to disturbance and resistance to cheatgrass of a sagebrush ecosystem in central Nevada exhibiting pinyon and juniper encroachment

(b) Post-fire recovery of native understory species on a study site with high resilience to fire and resistance to invasive species

(c) Post-fire invasion of exotic annual grass, cheatgrass, on a study site with low resilience to fire and resistance to invasive species

Climate Change and Wildfire Effects on Stream Temperatures and Thermal Habitat

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Temperature influences the health, abundance, and distribution of stream organisms. A warming climate is increasing stream temperatures and is cause for concern regarding the future health of stream ecosystems. RMRS scientists developed a temperature model that uses new spatial statistical techniques for stream networks with existing temperature measurements to interpolate accurate maps of thermal conditions across broad areas. This original research was conducted in the Boise river basin of Idaho and used a large interagency stream database consisting of 518 temperature monitoring sites. The stream temperature model explained 93% of the variation in mean summer temperatures and allowed scientists to assess the various effects of climate change and wildfire.

A healthy autumn stream

Results suggest that solar radiation increases following extensive wildfires accounted for 9% of temperature increases over a 14 year period, while climate related trends due to increasing air temperature and decreasing stream flow accounted for the remaining 91%. Wildfires had locally important effects within burn perimeters as stream temperature increases were 2 – 3 times greater than basin average temperature increases. The trends toward warmer stream temperatures caused small shifts in thermal habitats for rainbow trout to higher elevations. In contrast, bull trout lost approximately 11% - 20% of their thermally suitable habitats because upstream refugia for this species do not exist.

These findings suggest a warming climate has begun to affect thermal conditions but biological impacts will be both species- and context-specific. The approach to modeling stream temperatures developed by this research is currently under expansion for application across a five state area in the Northwest using a much larger temperature database consisting of more than 15,000 temperature monitoring sites. Outputs from the regional temperature model will ultimately provide accurate and consistent information regarding wildfire and climate effects for 350,000 kilometers of stream and 45 national forests.

For more information on GIS stream temperature data, visit www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.html

Bull and rainbow trout. Photo by the U.S. Fish and Wildlife Service

Perspectives on Risk in the Wildland-Urban Interface

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Our nation's forests have long been considered a refuge from the burdens and stresses of everyday life and have become a sanctuary for many. For these reasons, many people continue to move into these desirable areas of the U.S. where wildfires are a natural part of the ecological cycle.

As these wildland-urban interface (WUI) populations expand, it is important to understand what motivates residents to mitigate the risks associated with wildfires near their homes and communities.

RMRS scientists, along with resource economists from California State University, Long Beach, examined WUI residents' perspectives about the threats, risks, and conditions that can mitigate the risks of wildfire. The overarching question was how homeowners living in high-risk areas decide whether or not to mitigate the risks they face from wildfire.

Results indicate that motivation was consistently related to several factors including location, as full-time WUI residents were more motivated to mitigate wildfire risk than seasonal residents who primarily resided in suburban areas. Motivation was further influenced by individual perceptions of threat, determined largely by past wildfire experiences, and by individual ability to mitigate the risk. Lastly, scientists found a direct relationship between action and the individual's sense of responsibility to their individual home, community, or landscape at-large.

Uniformed firefighters working alongside a smoky blaze

Social scientific research is vital to understanding motivational factors that can influence residents' attitudes toward a more proactive approach in fire and fuels management. Land managers work to influence residents' attitudes and behaviors by establishing positive relationships, partnerships, and creating effective knowledge transfer programs to promote safety and mitigate wildland fire risk in WUI communities.

Lightning, a fire-starter in the WUI

Community Capacity, Social Diversity, and Adapting to Wildfire Risk in the Wildland-Urban Interface

Colorado WUI community

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In 2003, The Healthy Forests Restoration Act (HFRA) was enacted to reduce wildfire risk to communities and watersheds on or near federal land. The Act introduced the concept of the community wildfire protection plan (CWPP), which encourages communities in the wildland-urban interface (WUI) to collaborate on the development of plans to reduce their wildfire risk by identifying high priority areas for wildland fire mitigation and fuel reduction projects. Since the inception of HFRA, RMRS scientists have worked with communities to understand their capacity to organize and adapt to the threat of wildland fire.

Researchers found that the WUI represents a diverse mosaic of people and communities, from families who have owned their land for generations to individual seasonal visitors who spend only a few weeks a year in vacation homes. Notable social factors within these communities included variability in both social-economic status and knowledge related to culture, ecology, and wildfire history. Perhaps the most important aspect of social diversity was community capacity: a community's ability to recognize risks, process and evaluate those risks, and adapt to protect life and property. Yet community capacity was largely contingent upon leadership, organization, knowledge of and access to scientific and technical information about the local ecosystem and culture. These factors, which vary widely across WUI communities, contributed to community resiliency: the community's ability to react to change and emerge from disasters like wildfire with their essential identities remaining intact.

As communities develop their community wildfire protection plans, researchers and community leaders need to recognize the successes and challenges surrounding collaborative planning, and understand that a community's ability to adapt to natural resource risks depend largely on social context and community capacity.

For more information, visit www.fs.fed.us/rm/human-dimensions/staff/drwilliams.shtml

WUI home on Rattlesnake Fire. Montana 2007

The Wildland-Urban Interface and Risks to Natural Fire Regimes

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Elkbath, Sula, Montana, 2000. Photo by John McColgan of the Alaskan Type I Incident Management Team

Many ecosystems in the West are dependent on natural fire regimes to maintain their health. In forests, fire promotes seed germination, thins competing young trees, and creates a patchwork of multi-aged forest stands. Yet, across the West, the future of managing wildfire as a natural ecological process is at risk because longer, drier fire seasons and increased population densities in the wildland-urban interface (WUI) can make fire suppression the only management option.

RMRS scientists from the Aldo Leopold Wilderness Research Institute are examining the past, present, and future role of wildland fire in shaping wilderness ecosystems. By using fire behavior models and case studies, researchers have been evaluating management tradeoffs between fire suppression decisions and/or the restoration and maintenance of natural fire regimes. Researchers found that active suppression of natural ignitions in the WUI to protect people and property can alter natural fire regimes inside wilderness, thereby also affecting fire-adapted ecosystems dependent on those regimes.

Natural fire regimes in wilderness can also be altered if human-caused ignitions in the WUI increase and exceed historic fire frequency levels; such increases could threaten the persistence of native plant species. Further changes in temperature, snowfall, and snowmelt could dramatically impact the number, extent, and duration of future wilderness fires. For example, earlier snowmelt at high elevations could lead to earlier fuel moisture declines, and inevitably lead to increased flammability earlier in the season for longer periods of time. As communities develop their community wildfire protection plans, researchers and community leaders need to recognize the successes and challenges surrounding collaborative planning, and understand that a community's ability to adapt to natural resource risks depend largely on social context and community capacity.

In case studies of Yosemite and Sequoia-Kings Canyon National Parks, retrospective modeling indicates that if some past ignitions were allowed to burn, many areas would now be much closer to their natural fire regimes. Scientists hypothesize that landscapes where wildfires are allowed to burn may naturally moderate future wildfire size and severity. These modeling results complement field-based research which suggests that landscapes allowed to burn in accordance with their natural fire regimes may be more self-regulating over time because wildfires reduce fuel loads and create fire breaks which limit the size and severity of wildfires.

Mapping Current and Potential Biomass Flows from National Forest Treatments

Forest contractors remove biomass to be used in the cogeneration of heat and power during an RMRS forest operations research study with industry partners

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Forest fuel reduction treatments to manage fire hazards and improve forest health produce large quantities of woody biomass byproducts including limbs, tops, and low-grade logs. In 2010, RMRS scientists, US Forest Service land managers, and the Bureau of Land Management began a research collaboration to understand the social, economic, and ecological feasibility of using biomass byproducts collected from forest treatments on the Uncompahgre National Forest in Colorado. This research collaboration, which is linked to the 10-year Grand Mesa, Uncompahgre, and Gunnison National Forest Uncompahgre Plateau Collaborative Forest Landscape Restoration Program, examined potential energy sources from biomass to include the production of heat, power, liquid fuels, and other byproducts.

Using quantitative and qualitative methods, RMRS scientists measured landscape-level stocks, current biomass flows, and potential flows that could be available under alternative scenarios. They analyzed and quantified net greenhouse gas emissions, carbon balance, and energy balance associated with alternative configurations of biomass use, including co-firing with coal. They then estimated the costs of delivering biomass feedstock to both existing and potential new energy producers in the region by evaluating conditions under which biomass utilization would potentially deliver the greatest net economic and environmental value.

Research partners Carmine Lockwood (GMUG National Forests) and Jim Free (Uncompahgre Partnership) stand next to biomass produced from aspen regeneration treatments on the Uncompahgre Plateau, CO

RMRS Research Forester Nate Anderson shares the results of the study with stakeholders during a public meeting in Montrose, CO

Research results revealed that most stakeholders were generally supportive of biomass because Collaborative Forest Landscape Restoration Program treatments could produce up to 30,000 additional tons of recoverable biomass per year at an average cost of $35 to $50 per ton. This research is not only essential for economic development but can also deliver beneficial environmental results and improved air quality emissions when compared to traditional fuel burning for disposal.

For more information on this project, visit www.fs.fed.us/rm/raster-utility/project or uplandscape.org/woody-biomass/

Fuel Management and the Post-Fire Environment

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Forest vegetation is the fuel for wildland fires. Vegetation that spans vertically serves as ladder fuel between the forest floor and the forest canopy and allows wildfire to transition from a low-intensity surface, or ground fire, to a high-intensity crown fire as it climbs vertically. Vegetation that spans horizontally and closer to the forest floor allows fire to spread in surface area until the fuels, or vegetation, is interrupted. Consequently, forest thinning, pruning, and prescribed fire are common fuel reduction treatments for land management.

RMRS researchers examined the effectiveness of forest thinning and prescribed fire treatments on two fire-adapted landscapes where fuel treatments were followed by unexpected wildfires—the 2003 wildfire of the Missouri Breaks of eastern Montana and the 2007 Cascade Complex wildfires in central Idaho. The primary goal of these retrospective studies was to identify forest stand structure characteristics that managers could alter in order to maintain resilient forests and promote ideal post-fire outcomes such as wildlife habitat enhancement and the reintroduction of natural ecological processes.

Firefighters suppressing wildland fire behind treated fireline

Post-fire analysis revealed variable outcomes that were influenced by fuel moisture, weather, and topography. In the 2003 study, results showed that prescribed fire followed by wildfire resulted in stands of live mature trees, reduced understory fuels, and created forest conditions that may have occurred under historical natural fire regimes that burned with more frequency and less intensity. Whereas the 2007 study revealed that a combination of prescribed fire, mechanical treatments, and forest thinning did not stop or slow progression of the wildfires but instead provided safe areas, via treated units, to delineate fireline construction zones. This allowed firefighters safe access to suppress spot fires near structures in the Wildland-urban interface and altered post-fire outcomes by favoring tree survival and maintaining floor and soil nutrients.

For more information, visit www.fs.fed.us/rm/pubs/rmrs_gtr229.html

Crown fire created by ladder fuels

Spatial Variability of Wildland Fuel

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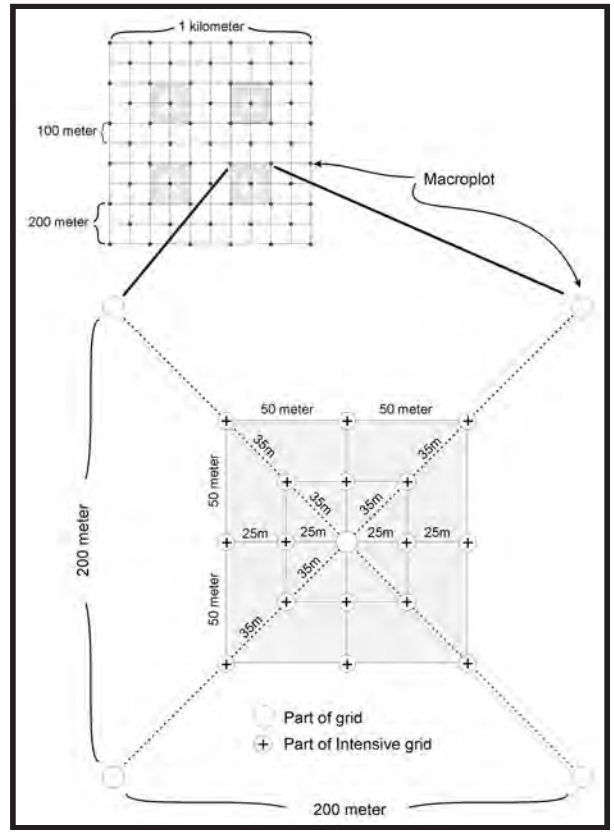
Wildland fuel is the one factor that can be directly manipulated to achieve fire management goals, such as lowering fire intensity, minimizing plant mortality, reducing erosion, and restoring fire-adapted ecosystems. Fire behavior fuel models frequently assign the average of fuel values across large areas, ignoring the extraordinary influence that fuel variability can have on wildland fire processes. Therefore, the great variability of fuel loading in one area could have more of an effect than the loading average on fire behavior, and also on post-fire plant mortality, growth, and colonization dynamics.

Fuel variation of the six sites selected for this study

A comprehensive description of fuels is needed for nearly all phases of fire management, including fighting wildfires, implementing prescribed burns, describing fire danger, and predicting fire effects. Yet fuels are difficult to describe due to the great variability of fuelbed characteristics. RMRS scientists have quantified the spatial variability of surface and canopy fuel characteristics for dry forest and shrub ecosystems of the northern Rocky Mountains.

Results show that most surface fuel components have very high variability in both amounts present (fuel loading and bulk density) and characteristics (fuel density and mineral content). On the other hand, canopy fuel properties (canopy loads and bulk density) have much less variability than surface fuels and vary over larger spatial scales–ranging from 100 to 400 meters. Results from this study will be used to redesign wildland fuel inventory, monitoring, and mapping programs to account for spatial variability in sampling methods.



The sample grid installed in the center of each study area with the four areas that received additional sampling to intensify the grid. A set of nested plots were installed at each of the sample points shown

To learn more about fuel dynamics research, visit www.firelab.org/research-projects/fuel-dynamics/55-fuelvar

Index for Characterizing Post-Fire Soil Environments in Temperate Coniferous Forests

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Many scientists and managers have an interest in describing the post-fire environment to understand the effects on soil productivity, vegetative growth, and wildlife habitat. Yet minimal research has focused on the scientific rationale for classifying the post-fire environment.

RMRS scientists and collaborators from the U.S. Geological Survey and University of the South developed an empirically grounded soil post-fire index (PFI) based on available science and ecological thresholds. Through a vast literature synthesis, researchers identified five broad categories of post-fire outcomes: (a) unburned, (b) abundant surface organic matter (>85% surface organic matter), (c) moderate amount of surface organic matter (≥40 through 85%), (d) small amounts of surface organic matter (<40%), and (e) absence of surface organic matter (no organic matter left); then subdivided each category on the basis of post-fire mineral soil colors to provide a more fine-tuned post-fire soil index.

Additionally, each PFI category was related to characteristics such as soil temperature and duration of heat during fire, and physical, chemical, and biological responses. Because fire is an important disturbance in many temperate forests, consistent classifications and descriptions of post-fire soil conditions are advantageous. They not only provide opportunities to improve the application and interpretation of scientific results, but also enhance multi-disciplinary planning and the management of fire-dependent forests. Therefore, the PFI index will be a useful tool for post-fire assessments and NEPA planning.

For more information on this project, visit www.fs.fed.us/rm/pubs_other/rmrs_2012_jain_t001.pdf

(a) Absence of surface organic matter

(b) Abundance of surface organic matter

Science Delivery of National Fire Plan Research from the Rocky Mountain Research Station (RMRS)

From 2009 to 2012, the RMRS Science Application and Integration Program received National Fire Plan funding to aid RMRS scientists in the delivery of National Fire Plan research to key stakeholders. During this period, 45 projects were funded: 14 integrative projects (assessments, syntheses, and decision support tools), 15 web resource projects (website development, online workshops, reports, and publications), 5 interactive technologies projects (webinars, videos, and interactive mapping tools), and 11 training sessions. Three of these science delivery projects are highlighted here:

1. Adapting the Watershed Erosion Prediction Project Model to the Burned Area Emergency Response Protocol

Lead Scientists: Bill Elliot and Pete Robichaud
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Soil erosion, stream water quality, and stream water flow are of great concern following a wildfire. Fires not only consume vegetation, they also affect soil structure and hydraulic properties, which can lead to flooding risks and excessive sedimentation in forest streams. These conditions can degrade water quality and damage downstream values, such as campgrounds and aquatic habitat. Immediately following a large wildfire, the Forest Service assembles teams of specialists to carry out a Burned Area Emergency Response (BAER) analysis to identify post-fire values at risk and options for mitigation.

RMRS National Fire Plan science delivery funding from 2009 to 2011 was a key contributor to developing erosion and flood prediction tools to aid BAER Team Specialists. A suite of four complementary tools were developed for BAER Teams. They are all based on an interagency hydrology and erosion model, the Water Erosion Prediction Project (WEPP) model. The WEPP model is particularly useful for BAER work in the Western U.S. because it can incorporate remote microclimates, estimate extreme events, and model snow melt processes. Because of the format of WEPP's input and output files, it has been possible to develop a series of custom interfaces for WEPP to meet BAER team needs.

- The simplest interface for BAER teams is the **Erosion Risk Management Tool, or ERMiT**, that predicts the probability of a given amount of sediment delivery from a given hillslope. ERMiT also predicts the benefit of three common BAER post-fire mitigation treatments: log erosion barriers placed on the contour on burned hillsides, seeding and mulching, a practice RMRS research has shown to be particularly effective in reducing runoff and erosion from burned hills. One of the outputs from ERMiT is a table of large runoff events and the storms or snowmelt events that caused them.
- A second interface, the **Peak Flow Calculator**, has been developed to use this information from ERMiT, along with details of watershed topography, to predict the risk of flood flows.
- A third batch processor tool, based on Excel, aggregates hundreds of individual hillslope outputs from ERMiT to allow teams to analyze sediment delivery across an entire burned landscape.

Complementary GIS tools were developed to provide topography and burn severity for the batch processer, and to analyze the distribution of erosion risk within burned landscapes either as an annual value, or for a single large storm.

For more information, visit forest.moscowfsl.wsu.edu/BAERTOOLS/

Flooding from a small watershed following the Wallow Fire in Arizona in 2011. Photo by Joseph Wagenbrenner

2. OptFuels: Fuel Treatment Optimization

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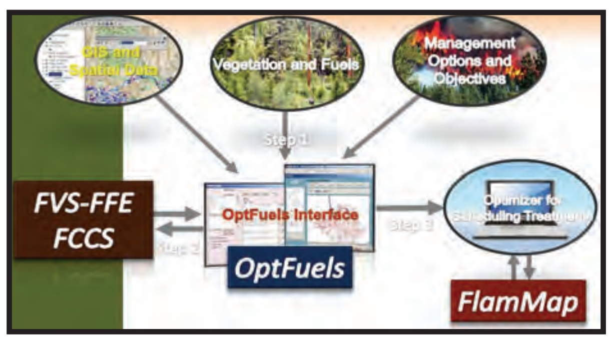
RMRS scientists in collaboration with scientists from the University of Montana developed OptFuels to help land managers prioritize forest fuel reduction treatments and optimize locations for fuel treatments to minimize expected loss, reduce fire costs, and ultimately operate within fiscal and operational constraints. OptFuels provides automated data transfer between five models to analyze fuels and fire behavior, stand-level effects of treatments, and priority planning for land management. It adds a fuel reduction optimizer to support not only long-term management decisions but also to recommend optimal locations for fuel treatments. Through National Fire Plan science delivery funding, a demonstration model, automated tutorial, 3-D landscape display, workshop, and web page were created.

For more information, visit www.fs.fed.us/rm/human-dimensions/optfuels/main.php



OptFuels Components

3. A Comprehensive Guide to Fuels Management Practices for Dry Mixed Conifer Forests in the Northwestern United States

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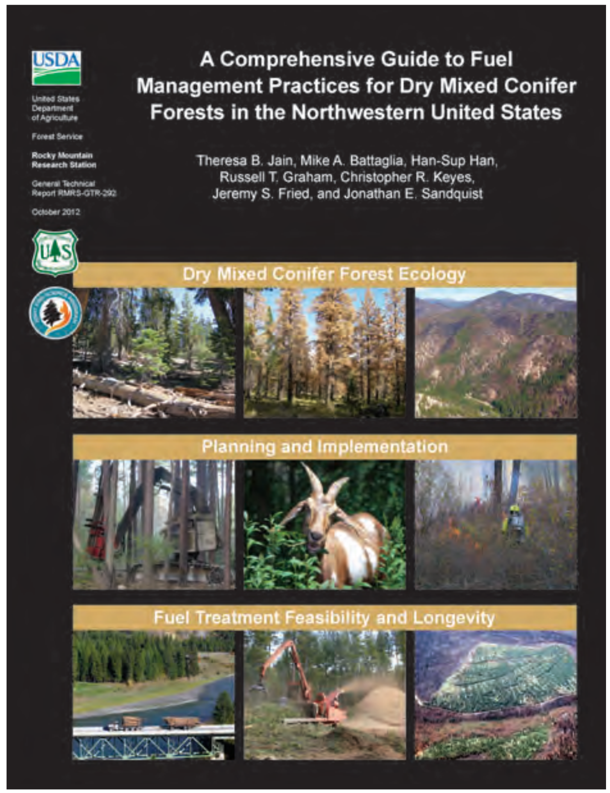
RMRS researchers along with collaborators from Humboldt State University, the University of Montana, and the Pacific Northwest Research Station composed a synthesis of information on the ecology, management strategies, and effectiveness of fuel treatments within the dry mixed conifer forests of the northwestern United States. The Report, "A Comprehensive Guide to Fuels Management Practices for Dry Mixed Conifer Forests in the Northwestern United States" (RMRS General Technical Report No. 292), is a compilation of best practices for land management. Because dry mixed conifer forests cover such a broad and diverse region of forested landmass, researchers made site-specific visits to federal, state, tribal, and local land management organizations to conduct over 50 interviews with resource specialists in eight states. By incorporating the most relevant scientific research and best practice approaches, scientists used this information to develop an organizational framework to support land management strategies. Forest Inventory and Analysis information was used to assess current conditions and economic feasibility. This publication is intended to enhance cross-disciplinary communication among key stakeholders and land managers.

For more information, visit www.fs.fed.us/rm/pubs/rmrs_gtr292.html



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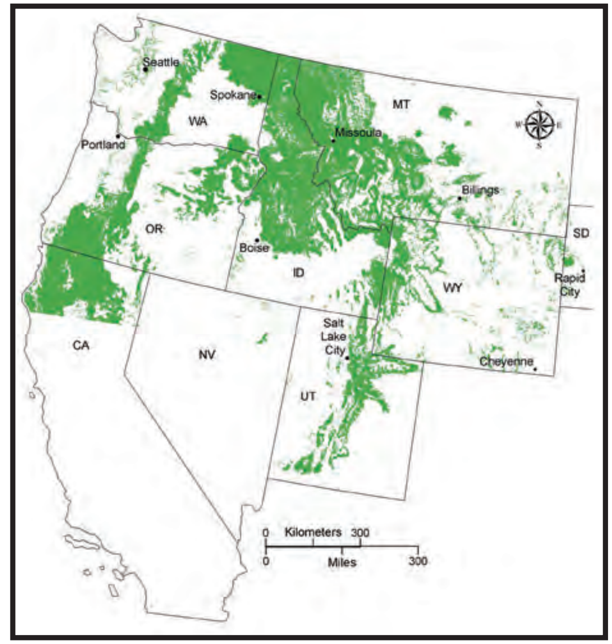

Fuels synthesis area

Research, Development, and Application (RD&A) Programs at RMRS

The Rocky Mountain Research Station Science Application and Integration Program hosts two RD&A programs: the Wildland Fire Management RD&A, and the Human Factors and Risk Management RD&A. The forest service charters these programs to integrate and synthesize cutting-edge research to develop technologies and tools to support the fire management community. RD&A programs are national in scope and focus on science application and delivery.

Wildland Fire Management RD&A Program

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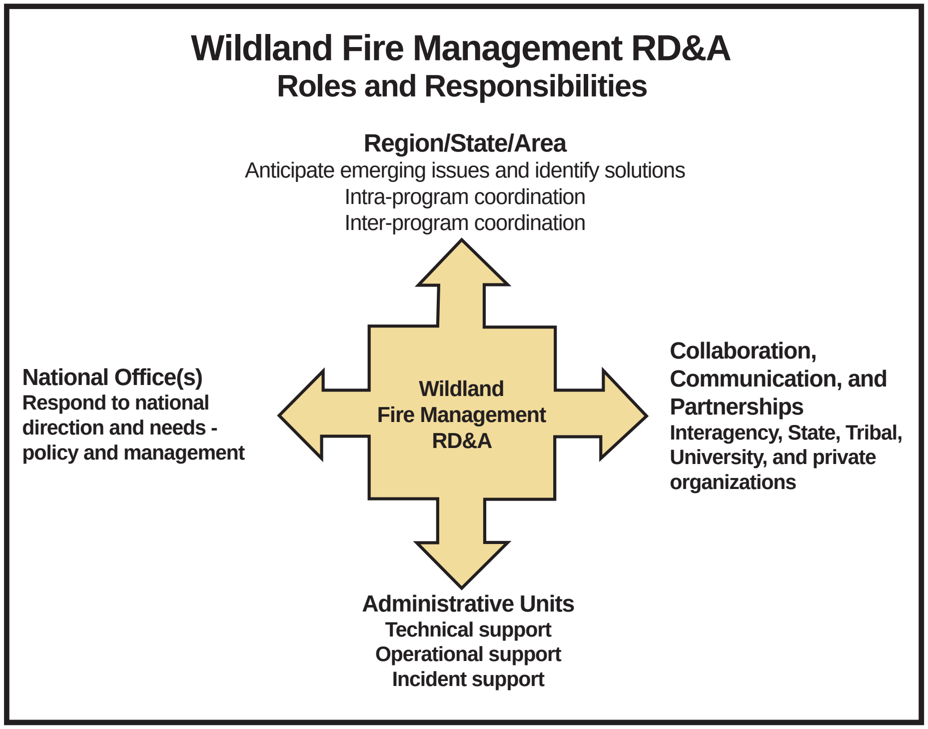
The Wildland Fire Management RD&A serves as point-of-contact for communication between scientists and field managers. Researchers provide science application services to the national interagency wildland fire community and guide the development and application of wildland scientific knowledge, and decision support tools by:

- Coordinating fire science application.
- Developing and supporting the Wildland Fire Decision Support System.
- Projecting fire season costs.
- Coordinating scientific efforts associated with wildland fire costs.
- Participating in developing hazardous fuels planning applications.
- Managing the National Fire Decision Support Center.

For more information, visit www.wfmrda.nwcg.gov/



Human Factors and Risk Management RD&A Program

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The Human Factors and Risk Management RD&A is helping the Forest Service develop a high performance health and safety culture that is highly reliable and resilient; one where employees take a proactive and systematic approach to managing risk. Researchers with the RD&A synthesize state-of-the-art psychological and social science to provide support for investigations of serious accidents, facilitated learning analyses, and incident reviews of escaped prescribed fires. Working with a variety of partners, they undertake high-priority research to:

- Improve organizational performance with robust organizational learning from escaped prescribed fire reviews.
- Benchmark safe and high reliability practices in federal wildland fire crews.
- Develop wildland fire leadership using mindfulness and self-compassion.
- Plan incident management organization succession.

For more information, visit www.fs.fed.us/rm/human-factors/

Comprehensive well-being session at the Modoc National Forest

RMRS, the Leader in Wildland Fire Research, Continues to be One of America's Greatest Research & Development Investments:

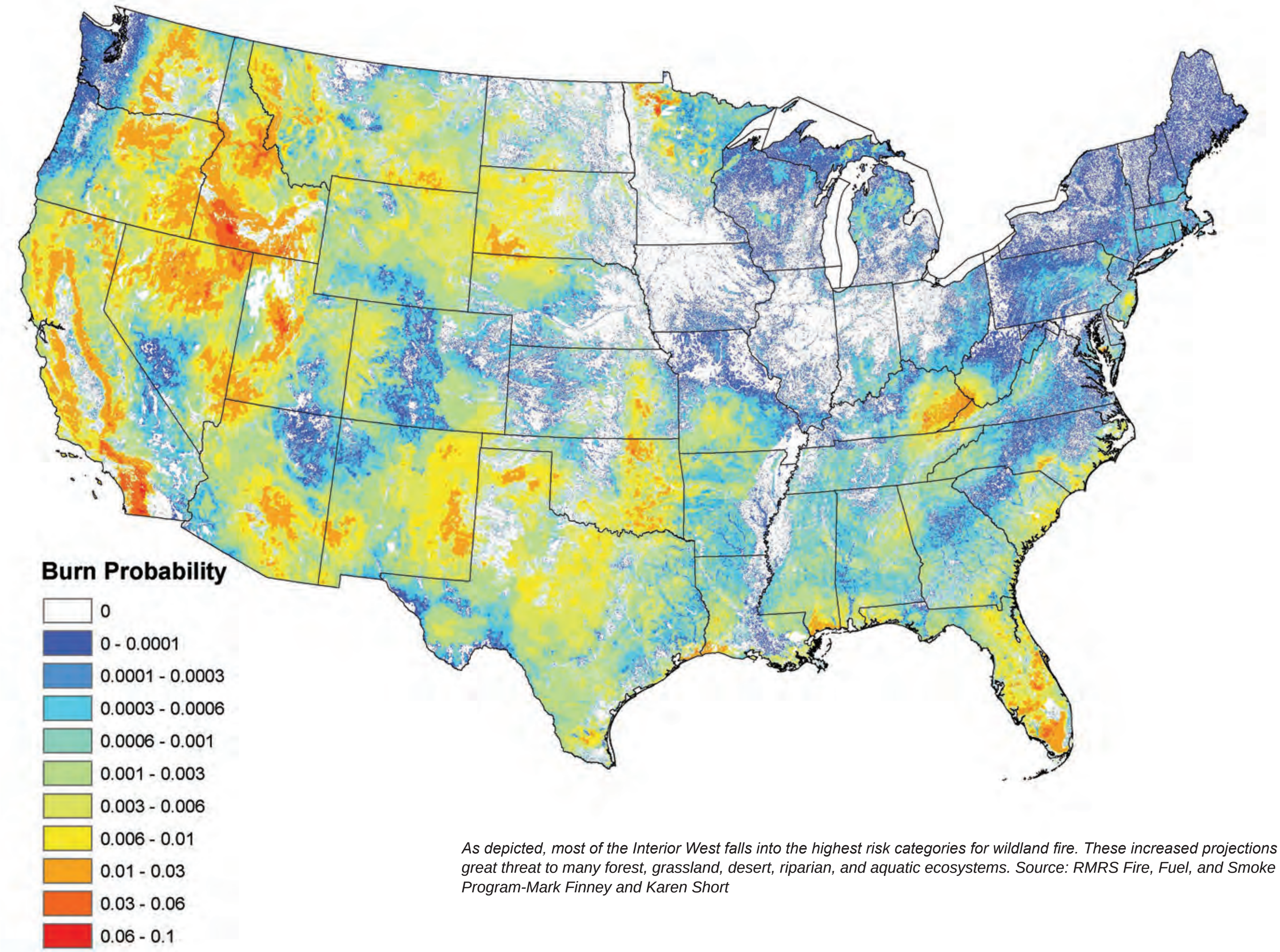
- We maintain the world's only one-of-a-kind Fire, Fuel, and Smoke Science Program and Fire Sciences Laboratory in Missoula, MT.
- We house the Wildland Fire Management Research Development and Application program, a nationally chartered organization established in 2006.
- Our scientists are the "go-to" experts for Congressional fire-related studies.
- We produce relevant and timely peer-reviewed natural resource research publications year round.
- We maintain global partnerships with hundreds of cooperators worldwide, to include universities, non-profits, and federal, state, tribal, and local agencies.
- Our research staff employs world renowned scientists and Nobel Laureates.

- We maintain 12 research laboratories and 14 Experimental Forests and Range (EF&R) locations across a 12-state territory encompassing the Great Basin, Southwest, Rocky Mountains, and parts of the Great Plains.
- The Station employs over 400 permanent full-time employees, including over 90 research scientists, who conduct research that spans an area containing:
    - ♦ 52% of the nation's National Forest System lands.
    - ♦ 54 National Forests and Grasslands.
    - ♦ 55% of the nation's BLM lands.
    - ♦ 37% National Park Service lands.
    - ♦ 41% non-urban/rural private land, and numerous other public and tribal lands.

RMRS research continues to develop and deliver scientific knowledge and technology that helps sustain our forests, rangelands, and grasslands by:

- Creating credible, innovative, science-based solutions for resource management problems.
- Identifying relevant needs and quickly and efficiently converting science gaps into findings and products for managers and citizens.
- Anticipating and responding to emerging issues.
- Enhancing the ability of our customers and partners to more easily find, participate in, and use products of the RMRS research program.

2012 Burn Probability Map for the Conterminous United States Generated for Risk Assessment and Other Applications:



As depicted, most of the Interior West falls into the highest risk categories for wildland fire. These increased projections pose a great threat to many forest, grassland, desert, riparian, and aquatic ecosystems. Source: RMRS Fire, Fuel, and Smoke Science Program-Mark Finney and Karen Short

RMRS Science Program Areas

Air, Water and Aquatic Environments

Air quality, water availability, water quality, and aquatic habitats are critical issues within the rapidly changing Western United States. The Air, Water and Aquatic Environments program is committed to the development of knowledge and science applications related to air and water quality, as well as the habitat quality, distribution, diversity, and persistence of fish and other aquatic species.
www.fs.fed.us/rm/boise/awae_home.shtml

Fire, Fuel and Smoke

The Fire, Fuel and Smoke program works to improve the safety and effectiveness of fire management through the creation and dissemination of basic fire science knowledge. The program investigates the impacts of fires on the environment by means of fundamental and applied research for understanding and predicting fire behavior, its effects on ecosystems, and its emissions into the atmosphere.
www.firelab.org/

Forest and Woodland Ecosystems Science

Forests and woodlands are increasingly being impacted by large scale urbanization and human developments, uncharacteristically large and severe wildfires, insect and disease outbreaks, exotic species invasions, and drought, and interactions of multiple stressors at local, landscape, and regional scales. The Forest and Woodland Ecosystems Science Program acquires, develops, and delivers the scientific knowledge for sustaining and restoring forests and woodlands landscape health, biodiversity, productivity, and ecosystem processes.
www.fs.fed.us/rm/forest-woodland/

Grassland, Shrubland and Desert Ecosystems

Disruptions by large-scale clearing for agriculture, water diversions, extensive grazing, changes in the native fauna, the advent of alien weeds, altered fire regimes, and increases in human-caused insect and disease epidemics have contributed to produce areas that are in unsuitable condition. The Grassland, Shrubland and Desert Ecosystems program addresses the biology, use, management, and restoration of these grass and shrublands.
www.fs.fed.us/rm/grassland-shrubland-desert/

Human Dimensions

The Human Dimensions program provides social and economic science based innovation to human societies as they develop a sustainable relationship with their environment. Major issues confronting societies across the globe such as global climate change, energy, fire, water, and ecosystem services all have important social-economic dimensions that will be explored and addressed by this program.
www.fs.fed.us/rm/human-dimensions/

Inventory, Monitoring and Analysis

The Inventory, Monitoring and Analysis program provides the resource data, analysis, and tools needed to effectively identify current status and trends, management options and impacts, and threats and impacts of fire, insects, disease, and other natural processes.
www.fs.fed.us/rm/ogden/

Science Application and Integration

The Science Application and Integration program is a knowledge transfer unit that provides leadership for the integration and use of scientific information in natural resource planning and management across the Interior West.
www.fs.fed.us/rm/science-application-integration/

Wildlife and Terrestrial Ecosystems

The Wildlife and Terrestrial Ecosystems program is engaged in sustaining species and ecosystems of concern through studies of ecological interactions within and between plant, aquatic, and terrestrial animal communities; understanding public use effects through studies elucidating social and economic values associated with consumptive and non-consumptive uses of fish and wildlife; managing terrestrial and aquatic habitats; and evaluating outcomes of land and water uses and natural disturbances.
www.rmrs.nau.edu/wildlife/

Literature Cited

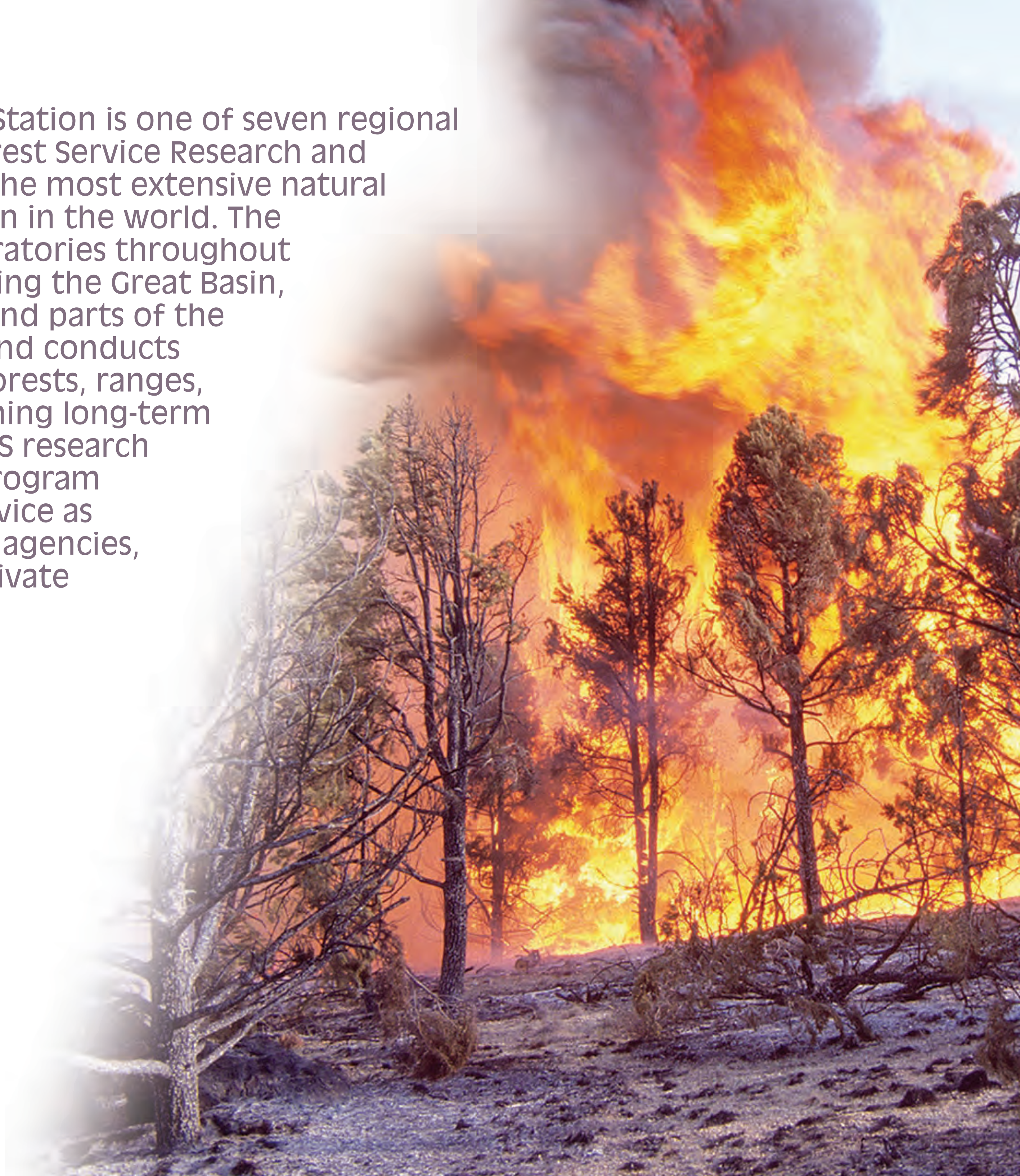
Steele, J. 2000. Effective firefighter safety zone size: a perception of firefighter safety. In 4th International Wildland Fire Safety Summit. Edmonton, AB Canada, Oct 10-12 2000. (Eds BW Butler, KS Shannon) pp. 171-177. International Association of Wildland Fire, Missoula, MT

U.S. Department of Agriculture (USDA) and U.S. Department of Interior (DOI). 2000. Managing the impact of wildfires on the communities and the environment: a report to the president in response to the wildfires of 2000.

USDA and DOI. 2002. A collaborative approach for reducing wildland fire risks to communities and the environment: 10-year comprehensive strategy, May 2002.

USDA Forest Service. 2006. Wildland fire and fuels research and development strategic plan: meeting the needs of the present, anticipating needs of the future, June 2006.

The Rocky Mountain Research Station is one of seven regional units that make up the U.S. Forest Service Research and Development organization — the most extensive natural resources research organization in the world. The Station maintains 12 field laboratories throughout a 12-state territory encompassing the Great Basin, Southwest, Rocky Mountains, and parts of the Great Plains, and administers and conducts research on 14 experimental forests, ranges, and watersheds,while maintaining long-term databases for these areas. RMRS research is broken into seven science program areas that serve the Forest Service as well as other federal and state agencies, international organizations, private groups and individuals.



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