National Fire Plan
Research And Development
2004-2005 Accomplishment Report

The progress and accomplishments of the U.S. Forest Service's National Fire Plan Research and Development for research findings, tool developments, technology transfer, and research highlights in four key areas:

- *Firefighting*
- *Rehabilitation and Restoration*
- *Hazardous Fuel Reduction*
- *Community Assistance*

United States Department of Agriculture

Forest Service

September 2007

Rocky Mountain Research Station

General Technical Report RMRS-GTR-200

Hilbruner, Michael W. and Paul Keller, eds. 2007. **National Fire Plan Research and Development 2004-2005 accomplishment report**. General Technical Report RMRS-GTR-200. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 73 p.

Abstract

This report highlights accomplishments achieved by USDA Forest Service National Fire Plan Research and Development projects from 2004 through 2005 in four key areas: firefighting, rehabilitation and restoration, hazardous fuels reduction, and community assistance. These highlights illustrate the broad range of knowledge and tools introduced and generated by the National Fire Plan Research and Development program.

In fond memory of Sue Ann Ferguson

You may order additional copies by sending your mailing information in label form through one of the following media. Please specify the publication title and number.

Telephone	(970) 498-1392
FAX	(970) 498-1122
E-mail	rschneider@fs.fed.us
Web site	http://www.fs.fed.us/rmrs
Mailing Address	Publications Distribution Rocky Mountain Research Station 240 West Prospect Road Fort Collins, CO 80526

Rocky Mountain Research Station
Natural Resources Research Center
2150 Centre Avenue, Building A
Fort Collins, CO 80526

National Fire Plan Research and Development is working to improve firefighting preparedness through tools and models developed to predict activities such as: wildfire behavior, aggression, intensity, and effects; smoke transport; and fire-weather forecasting. Results of this research are helping managers and national forest personnel to: fight fires cost effectively, increase firefighter safety, plan and conduct prescribed burns, and reduce wildfire damage to natural resources and society.

CONTENTS

Cover photographs by Dan Megna, Eli Lehmann, and Mark S. Moak.

In Memoriam:

Sue Ann Ferguson

February 11, 1953 – December 18, 2005

Dr. Sue Ferguson passed away December 18, 2005, on a gloriously beautiful, crisp, blue-sky Seattle day. Sue had been battling cancer for the past year and one-half. She leaves behind a legacy of accomplishments in her research and in her relationships with friends, family, and coworkers. With her enthusiasm, tenacity, and boundless energy, Sue was an inspiration to all who knew her.

Sue Ferguson sailing on Lake Washington in September 2005.

She enjoyed a 13-year career in avalanche forecasting before coming to wildland fire research at the USDA Forest Service's Pacific Northwest Research Station (PNW) in 1992. (She was a recognized world avalanche expert and wrote a book about avalanches.) At PNW, Sue worked as a research meteorologist with the Fire and Environmental Research Applications Team. Sue founded and led the Atmosphere and Fire Interactions Research and Engineering (AirFIRE) Team.

She also provided the vision for and helped establish the Northwest Regional Modeling Consortium, a multiagency effort to develop improved weather forecasts. Using these predictions, she was able to offer land and fire managers tailored real-time forecast products that enhance and display existing fire weather indices such as the Haines Index, Fosberg Fire Weather Index, and a new dry lightning index.

Through the National Fire Plan, she created the BlueSky smoke-modeling framework, the innovative tool that—for the first time—allows users to see real-time predictions of cumulative smoke impacts from prescribed, wildland, and agricultural fire. This tool has been hailed as one of the preeminent research products to emerge from the National Fire Plan. It recently won the National Fire Plan's Excellence in Research Award.

The success of Sue's Northwest Regional Modeling Consortium and BlueSky smoke-modeling framework have prompted similar efforts around the country. Now—due to Sue's work and vision—real-time tailored forecasts of fire indices and smoke predictions are available throughout the lower 48 States.

Sue was also instrumental in the revival of the American Meteorological Society's biennial Fire and Forest Meteorology Conferences. Through her dedicated work, the utility of meteorology in fire research has been elevated to an unprecedented level. Her efforts continue to benefit and assist managers and researchers in the fire management field.

Sue Ferguson will be sorely missed. Her talent and wisdom and her infectious laugh, smile, and good humor made us all better for being with her.

I Introduction

The importance of hazardous fuel reduction and community assistance research is underscored by outcomes like southern California's 2003 wildland-urban interface fire siege (pictured here) that claimed the lives of 23 private citizens who were fleeing their flame-surrounded homes. Photos: Dan Megna.

Science-based knowledge and tools developed by National Fire Plan Research and Development are being used by this country's land managers to:

- ❖ Better predict potential fire hazard, fire growth, and smoke impacts;
- ❖ Evaluate fire behavior and fire severity more accurately and rapidly;
- ❖ Improve planning for post-fire rehabilitation;
- ❖ Better understand the effects of fuel treatments on fire behavior; and
- ❖ Evaluate the economic costs and benefits of fuel treatments and alternative forest products.

This new National Fire Plan-generated research information and associated tools also help our:

- ❖ Communities and homeowners better understand what can be done to reduce wildland fire risk;
- ❖ Wildland managers understand how to best work with these communities in collaborative planning efforts;
- ❖ Wilderness managers to better predict where fires can be allowed to burn naturally *without* causing severe ecosystem damage or hazards to communities; and
- ❖ Scientists better understand the impacts of fire and fuel treatments on aquatic systems and fish populations.

National Fire Plan-funded research providing vital tools to Federal, State and local governments

In the fourth and fifth years, the National Fire Plan Research and Development program, managed by the Forest Service, conducted research and—together with managers—brought science into application to aid in addressing wildland fire issues facing the country.

While much of the work centered around the three flagship fire research laboratories located in Missoula, MT, Seattle, WA, and Riverside, CA, scientists from all Forest Service Research Stations and the Forest Products Laboratories pursued Research and Development goals in all 50 States.

Seventy-two research teams continued to: establish new agreements with universities and other research partners; produce publications and decision-analysis tools; provide training; and transfer new information and technologies to managers, policymakers, and the public through Web sites, field tours, presentations, and other means.

Scientists funded by the National Fire Plan built on newly developed tools and databases to provide critical assistance to Federal, State, and local governments as they responded to the numerous fires experienced in the exceptional fire years of 2004 and 2005.

Fire research continues to address crucial National Fire Plan needs in four key areas

Guided by the strategic goals outlined in the National Fire Plan and the *10-year Comprehensive Strategy and Implementation Plan,* fire research continues to actively address crucial needs in these four key areas:

Firefighting Capacity

Provide better models of weather, fire behavior, smoke and other tools for improving firefighter decisions.

Rehabilitation and Restoration

Provide rapid response information and models to help restore landscapes and protect communities from the aftereffects of fire.

Hazardous Fuel Reduction

Develop improved analysis tools for determining the effects and economic tradeoffs of treatments intended to reduce fire risk by removing hazardous fuel (combustible forest materials).

Community Assistance

Work with communities to understand their needs and priorities, develop new approaches and materials for education, and recommend acceptable approaches to ensure adequate community protection from wildfire.

II Background

Considerable progress achieved in reducing hazardous fuel and assisting communities

The National Fire Plan—initiated in 2001 in response to the devastating 2000 fire season (table 1)—helps to support the enhancement of vital fire management and fire research activities.

The severe fire seasons in the new millennium further reinforced this need for:

- An aggressive and coordinated management response,
- The science needed to support this response, and
- Knowledge about fuel conditions that predispose landscapes to large, uncharacteristically destructive wildfires.

In 2004 and 2005, the Forest Service and the Department of the Interior made considerable progress in reducing hazardous fuel and assisting communities in preparing for wildland fire.

In support of these efforts, the National Fire Plan Research and Development program, in conjunction with other Forest Service R&D activities, accelerated efforts to improve the agency's:

- Science base,
- Analysis, and
- Decision-support tools for fire and fuel.

Three Core Research Programs

The work described in this document outlines the National Fire Plan R&D program administered by the Forest Service. Fire-related research is also conducted by Forest Service scientists supported by the Forest Service's general R&D appropriation. The Joint Fire Science Program is an interagency fire science program in which the Forest Service also participates.

In addition, these three core programs are complemented by various partners, including:

- Numerous universities,
- The U.S. Geological Survey,
- The National Aeronautics and Space Administration, and
- The National Oceanic and Atmospheric Administration.

Table 1 – Number of Fires and Acres Burned on Federal and State Protected Lands From 2000 to 2005.

Date	Number of Fires	Acres
2005	66,753	8,689,389
2004	65,461	8,097,880*
2003	63,629	3,960,842
2002	73,457	7,184,712
2001	84,079	3,570,911
2000	92, 250	7,393,493

*2004 statistics do not include North Carolina

Statistics provided by the National Interagency Fire Center on April 2, 2007. This information is available at http://www.nifc.gov.

National Fire Plan Research and Development Program benefits prove to be multifaceted

The benefits of National Fire Plan Research and Development are multifaceted. In addition to making research available through the standard outputs such as publications in journals, proceedings, and agency research papers, National Fire Plan Research and Development teams also focus outputs specifically designed to meet the needs of management and policy decisionmakers.

During fiscal years 2004 and 2005, National Fire Plan Research and Development research funds provided:

- ❖ Development of science synthesis documents and products;
- ❖ Development of useful models and tools for analyzing management alternatives;
- ❖ Critical advice to managers on fuel treatments, restoration, rehabilitation, and invasive species management;
- ❖ Evaluation of the effects of post-fire treatments and fuel treatments;
- ❖ New tools and data on active fire incidents to managers;
- ❖ Development of new training materials and Web sites for disseminating information;
- ❖ Education for managers, policymakers, and citizens on related issues; and
- ❖ Collaboration with universities and other key science partners.

New Information and Tools Provided by National Fire Plan Research and Development

Recent progress under National Fire Plan Research and Development is providing new information and tools to:

- ❖ Improve firefighting effectiveness,
- ❖ Enhance recovery of burned ecosystems,
- ❖ Improve programs for hazardous fuel reduction, and
- ❖ Enhance community preparedness.

National Fire Plan Research and Development Funding and Teams

The National Fire Plan Research and Development program was initiated in 2001. Available funds to conduct National Fire Plan research have remained relatively constant since the program began.

A total of $22.3 million in funding was appropriated in 2004. In 2005, this amount dropped to $21.7 million.

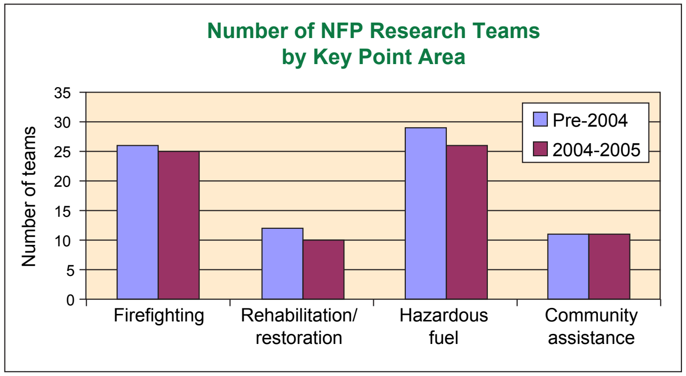
In both 2004 and 2005—as in previous years, and based on appropriation language—program funds were disbursed to the University of Montana Landscape Fire Center and to the University of Idaho to support the Fire Research and Management Exchange System (FRAMES) project. In addition, some funding was retained for national program support and special projects.

In the first year, 2001, funds were awarded to 72 research teams; 6 more were added in 2002.

There was a 5-year commitment period with the provision that funding could be extended contingent on evolving fire Research and Development priorities, available funds, and program performance.

In 2004, due to declines in the appropriation and other supporting program funds, 6 of the 78 research teams were unfunded (see figure below).

(See table in appendix for the “National Fire Plan Research and Development Program Projects and Team Lead Scientists” that displays the distribution of the research teams among the National Fire Plan key points—and identifies the 6 teams for which funding was dropped.)



Where is National Fire Plan Research and Development taking place?

The National Fire Plan Research and Development Program is national in scope and supports research in all 50 States. The program seeks to balance priorities and funding to meet needs across the country in key points of the National Fire Plan. The research involves Forest Service research teams and many cooperators from universities, the private sector, and non-Federal agencies. Many Forest Service research teams have broad national or regional missions and expertise. Research conducted at one location is often applicable across broad geographic areas.

III Accomplishments
in the Four Key Research and Development Areas

Firefighting Accomplishments

As this chapter outlines, National Fire Plan Research and Development is improving firefighting preparedness through tools and models that predict:

- Wildfire behavior, aggression, intensity and effects;
- Smoke transport; and
- Fire weather forecasting.

This research—illustrated and explored in the following pages—is helping our natural resource managers and national forest and rangeland staff to:

- Fight fires cost effectively;
- Increase firefighter safety;
- Better plan and conduct prescribed burns; and
- Reduce wildfire damage to natural resources and society.

Firefighting Accomplishments

Enhancing firefighting capability and fire preparedness

Weather forecasting models are needed that allow for more accurate prediction of fire-weather conditions and smoke transport and dispersion. Existing weather models have not been systematically applied to forecasting fire weather conditions. Thus, to enhance fire fighting capability and fire preparedness, scientists are working together in a regional consortium to develop improved forecasts of fire weather and smoke transport. This is one of several coordinated projects looking at predicting and modeling fire weather.

Project Identifier: **Heilman et al., 01. NCS.A. 1, North Central Research Station.**
Lead Scientist: **Warren Heilman, wheilman@fs.fed.us, 517-355-7740 ext. 110.**

Improving fire season severity predictions by examining relationships between climatic patterns and other indicators

Assessing the severity of the upcoming fire season is key to efficiently allocating fire suppression resources. Researchers are taking a new approach to improving fire season predictions by looking at the relationships between major climatic patterns and various environmental indicators of severe wildfire conditions. The information generated will help managers in wildfire preparedness efforts and will also be useful for the management of prescribed fires. This is one of an array of coordinated projects looking at predicting and modeling fire weather.

Project Identifier: **Goodrick, 01.SRS.A.4, Southern Research Station.**
Lead Scientist: **Scott Goodrick, sgoodrick@fs.fed.us.**

Photo by Ben Croft

Running crown fire produces massive flame lengths and boiling smoke column on the Pasayten Wilderness in the Pacific Northwest Region. Photo by Eli Lehmann, U.S. Forest Service.

Models will allow managers to evaluate fish and wildlife risks prior to making resource management decisions

Debate continues over how to manage fish and wildlife resources on federal lands in light of disturbances such as wildfires. Resolving the debate will require information on how wildfires and treatments implemented during and after fire affect these resources. Researchers are developing models that will enable managers to evaluate risks to fish and wildlife *prior* to making resource management decisions.

Project Identifier: **Lee, 01.PSW.A.1, Pacific Southwest Research Station.**
Lead Scientist: **Danny C. Lee, dclee@fs.fed.us, 707-825-2965.**

Improving fire severity model predictions

Fuels such as shrubs, old stumps, duff, and moss layers are not well represented in models currently used by fire managers to predict fire behavior and fire effects. Because of this lack of data, researchers are working to develop a new system to predict smoldering combustion and fuel moisture that better represents these types of fuels. This research will be used to predict the residence times in each combustion stage, and to predict the thresholds of flammability in many fuel types. The revised models will enable managers to make better predictions of fire danger and fire severity involving residual combustion, fire effects, and the opportunities for fire use.

Project Identifier: **Sandberg, 01.PNW.A.4, Pacific Northwest Research Station.**
Lead Scientist: **David V. Sandberg, dsandberg@fs.fed.us, 541-750-7265.**

New thermal imaging process reaps numerous benefits, including improved safety for firefighters

Airborne infrared imagers allow observers to "see through" smoke to detect lightning-ignited fires and to map fire areas. Imagers used in fire suppression today are limited in their ability to measure the very bright infrared light emitted by large wildland fires. Furthermore, infrared mapping aircraft are nationally deployed and thus may not be readily available for monitoring any given, fast-moving wildfire. New low-cost technology is needed to provide accurate tracking of fire intensity or activity, propagation, and immediate impacts. In response, scientists and engineers are developing and applying the "FireMapper" thermal-imaging radiometer to map and monitor major wildfires. Based on modern night-vision technology, the FireMapper is designed to accurately map surface temperatures associated with both major fire fronts and spot fires. Thus, this new imaging provides rapid fire intelligence to improve firefighter safety, make firefighting more effective, and reducing wildfire damage to natural resources and society.

Project Identifier: **Riggan, 01.PSW.A.4,**
Pacific Southwest Research Station.

Lead Scientist: **Philip J. Riggan, priggan@fs.fed.us,**
951-680-1534.

Targeting fuel reduction and fire management resources where they are most needed

Improving our understanding of ecological and social factors influencing fire regimes can provide insights into the vulnerability of different communities to wildfires. Researchers are developing a predictive model of fire frequencies using a number of ecological and social data including fuel types, climate, topography, ignition sources, road density, and ownership. Spatial statistics are being used to reconstruct the extent of historical fires observed by General Land Office surveyors in the 19^{th} century. This information, in conjunction with records of modern fires (1985-2000), is being used to derive spatially explicit estimates of historical and modern fire rotations associated with particular landscape ecosystems and land cover. Fire risk maps are being developed by overlaying these fire regime maps with maps of population and housing density. This will provide managers with a useful decision support tool for targeting fuel reduction and fire management resources where they are most needed.

Project Identifier: **Haight and Cleland, 01.NCS.A.2,**
North Central Research Station.

Lead Scientist: **Robert G. Haight, rhaight@fs.fed.us,**
651-649-5178.

Major breakthrough targets quantifying atmospheric pollutants from wildfire

To comply with the Clean Air Act and Regional Haze Rule requirements, it is necessary to forecast the transport of smoke over large regions. Researchers developed and validated an algorithm for mapping large fire burned areas in real-time by using Terra and Aqua satellite data. This major breakthrough allows fire scientists to quantify daily emissions of atmospheric pollutants from fires. It will also help land managers comply with air quality standards when planning for and conducting prescribed burns. Regional Haze Rule is a new U.S. Environmental Protection Agency rule promulgated under court order that requires visibility be protected in Clean Air Act Class I Areas (i.e., Forest Service wilderness, national parks, etc.) and returned to natural conditions by the year 2064.

Project Identifier: **Hao, 02.RMS.A.2, Rocky Mountain Research Station.**
Lead Scientist: **Wei Min Hao, whao@fs.fed.us, 406-329-4838.**

Study investigates smoke plume properties

Researchers are developing mobile instruments that can perform real-time measurements of particulate concentrations emitted by fires over large areas. Specifically, three prescribed burning experiments were conducted by using light detection and ranging (LIDAR) to study plume height and smoke dispersion. This proof-of-concept study demonstrated the utility of LIDAR for investigating smoke plume properties in harsh conditions.

Project Identifier: **Hao, 01.RMS.A.3, Rocky Mountain Research Station.**
Lead Scientist: **Wei Min Hao, whao@fs.fed.us, 406-329-4838.**

Exploring statistical models to evaluate the trade-offs and relative costs and benefits of fuel reduction measures

What are the relative costs and benefits of using various fuel reduction and fire suppression measures? Unfortunately, analytical tools for evaluating these trade-offs are not currently available at a regional scale. Scientists are therefore developing statistical models to evaluate these trade-offs. Linking cost and benefit information to alternative vegetation management strategies will improve efficiency of potential fire management programs and policies.

Project Identifier: **Prestemon, 01.SRS.A.2, Southern Research Station.**
Lead Scientist: **Jeffrey P. Prestemon, jprestemon@fs.fed.us, 919-549-4033.**

Improving fire behavior and fire season severity predictions in the rocky mountains and southwest

Because fuel loads and fuel energy potential are weather dependent, higher resolution weather and climatologic intelligence—beyond that currently available to fire managers—will improve fire behavior and fire season severity predictions. Scientists are working to establish the Rocky Mountain and Southwestern Interagency Modeling Consortium for research and operational mesoscale meteorological modeling to serve the Rocky Mountain area. This consortium joins the four fire weather modeling consortia established in 2001—and will eventually be linked to them.

Project Identifier: **Zeller, 02.RMS.A.1, Rocky Mountain Research Station.**
Lead Scientist: **Karl Zeller, kzeller@fs.fed.us, 970-498-1238.**

Wildfire burns on the Bridger-Teton National Forest 23 miles south of Jackson, WY. Photo by Jed Conklin, Spokesman Review, Spokane, WA.

Pilot test aims for consistent, national fuel condition monitoring system

Currently, no systematic measurements of forest fuel loading and fire potential is occurring anywhere across the United States. However, the Forest Inventory and Analysis (FIA) program does conduct annual inventories of the nation's forests. During the course of these inventories, research is also in progress for measuring fuel loading. Thus, this approach is providing critical information for validating remotely-sensed estimates of fuel loading. This scientific pursuit will provide the potential for a consistent, national basis for gauging the effectiveness of fire and fuel management policies.

Project Identifier: **May, 01.NCS.A.3,North Central Research Station.**
Lead Scientist: **Dennis May, dmay@fs.fed.us, 651-649-5132.**

Devising landscape assessment tools critical for the implementation of LANDFIRE project

This research project investigates various methods of mapping fuels, fire behavior, fire effects, and vegetation conditions to describe fire hazard and risk at multiple scales using simulation modeling, gradient analysis, and remote sensing. National Fire Plan funding was used to establish a team of scientists that conducts the core research for devising landscape assessment tools that are absolutely critical for the implementation of the LANDFIRE project (mapping fuel vegetation properties for the entire United States at 30 meters resolution). Without these National Fire Plan funds, the LANDFIRE project could not be successfully completed. Many research tasks must be completed to implement LANDFIRE.

Project Identifier: **Keane, 01.RMS.A.4, Rocky Mountain Research Station.**
Lead Scientist: **Robert Keane, rkeane@fs.fed.us, 406-328-4846.**

Developing methods to estimate haze from prescribed and wildland fires

The Regional Haze Rule recognizes that some prescribed fires substitute for natural fires in ecosystems. Consequently, prescribed fires are considered to be natural sources of visibility reduction. Regulatory agencies and land managers must establish the level of natural background visibility reduction; predict impacts from prescribed fires and wildfires in the near term—and out to 50 years in the future; and plan to eliminate human-caused visibility impairment by 2064. Researchers are developing methods to estimate and predict the natural and anthropogenic sources of regional haze. They are determining what visibility impacts can be expected from wildland fires and prescribed fires needed to restore and sustain ecosystem function. This information can be used to evaluate the air quality impact and acceptability of alternative fire management and fuel management strategies.

Project Identifier: **McKenzie, 01.PNW.A.2, Pacific Northwest Research Station.**
Lead Scientist: **Don McKenzie, donaldmckenzie@fs.fed.us, 206-732-7824.**

The Dexter Wildland Fire Use Fire consumes fuels on the Inyo National Forest, Photo by Jeff Bunker, U.S. Forest Service.

Establishing a research and technology transfer unit for southern interface areas

With the steady rise of new homes in this country's southern forestlands, wildland firefighters and small forest land owners need information and technology concerning the unique issues that surround preventing, fighting, and mitigating fire in the Wildland-Urban Interface. The Southern Research Station is establishing a center for fire prevention and pre-suppression information for federal, state, and local firefighting units in the South—with an emphasis on Wildland-Urban Interface issues.

Project Identifier: **Macie, O1.SRS.A.3, Southern Research Station.**
Lead Scientists: **Ed Macie emacie@fs.fed., 404/347-1647.**

Improving southern regional models for predicting smoke movement

Smoke modeling research is designed to answer an array of predictive questions for management. Several models are being designed to assist prescribed burners in knowing where and when residual smoke from prescribed burns can become trapped near the ground at night—and create visibility hazards that increase the potential for automobile accidents. "Rabbit" is a rule-driven fire spread model being designed to calculate prescribed fire spread rates during various firing methods. Data from Rabbit will replace the crude emissions production model now in place. The "Blowdown" model adapts PB-Piedmont code to weather radar data to simulate thunderstorm downdraft and outflow hazards. Blowdown gives short-range predictions of thunderstorm-caused wind shifts, and estimates how strong the wind will blow.

National Fire Plan Award Recipient

This project was recognized with a 2005 National Fire Plan Award for Excellence in Science for helping the health of firefighters and the public through improved smoke monitoring, modeling and management; and enhancing the restoration of longleaf/savanna ecosystems; and establishing a baseline for fuels reduction accountability.

Project Identifier: **Achtemeier, 01.SRS.A.5, Southern Research Station.**
Lead Scientist: **Gary L. Achtemeier, gachtemeier@fs.fed.us, 706-559-4239.**

Improving monitoring and modeling of smoke contributions to regional haze

Smoke can impact human health as well as agricultural and natural vegetation at locations distant from the actual fire. When smoke combines with industrial pollution from urban areas, the spatial extent and effects of smoke on remote areas may increase. Measuring these fire emissions and air chemistry in remote areas is difficult. However, new technical developments—such as passive samplers and portable active monitors for gaseous and particulate pollutants—are offering new research possibilities. Scientists are testing commercially available passive samplers for some important gaseous pollutants (ozone, nitrogen oxides and ammonia), and developing their own nitric acid vapor. These monitoring efforts provide an enhanced understanding of air pollution transport and distribution in complex mountain terrain. By monitoring the effects of several Lake Tahoe Basin regional fires, scientists have clearly demonstrated that most of the ozone and nitric acid vapor pollution in the Tahoe Basin is produced locally and does not result from long-range transport. Since 2003, scientists have also monitored concentrations of ozone, ammonia and nitric acid on the Kings River Project in the central Sierra Nevada and 18 monitoring sites in the San Bernardino Mountains. These scientists are now approaching the end of the 4th season of their air quality monitoring. Their observed new trends of air pollution distribution are much different from those 20-30 years ago. These new trends of pollution distribution patterns have been associated with a dynamic urban development of the Los Angeles Basin as well as in the Coachella Valley and the Mojave Desert. Results of their comprehensive and ongoing research is providing the information necessary for developing air pollution dispersion models and maps that will assist managers in planning for prescribed burns and control strategies for natural fires.

Project Identifier: **Bytnerowicz, 02.PSW.A.1, Pacific Southwest Research Station.**
Lead Scientist: **Andrzej Bytnerowicz, abytnerowicz@fs.fed.us, 909-680-1562.**

Highlight Projects

Firefighting Accomplishments

1. Bluesky – an award-winning modeling framework for real-time predictions of cumulative smoke impacts

This is the only effort that integrates all elements of the fire environment into a single modeling framework.

The Forest Service is now required to make better predictions of smoke movement and track fire emissions to better quantify the impacts of prescribed fire and wildfire on:

- Air quality,
- Visibility, and
- Regional haze.

In addition, impacts of smoke from prescribed fires often cause delays or cancellations that hamper effective fuel reduction programs.

Moreover, smoke impacts from wildfires can ground air resources and delay needed suppression activities. Smoke from all wildland fires affects human health. To mitigate these harmful impacts, coordinated communications of anticipated impacts are required.

To help meet these important challenges, researchers have designed and built "BlueSky," a Web-based system that provides predictions of smoke impacts in real time. This enables managers and public officials to:

- More effectively inform—and warn—of the impending impacts of smoke;
- Coordinate prescribed burn activities across land ownerships; and
- Track—each day—impacts of smoke on air quality, visibility, and regional haze.

What is BlueSky?

BlueSky is a modeling framework designed to predict cumulative impacts of smoke from forest, agricultural, and range fires. The BlueSky smoke modeling framework combines state-of-the-art emissions, meteorology, and dispersion models to generate the best possible predictions of smoke impacts across the landscape.

BlueSky has been created by a close collaboration of land management and air quality regulator users with scientific researchers. BlueSky is governed by the BlueSky Consortium—with the U.S. Forest Service AirFire Team taking the lead responsibility for scientific development.

BlueSky output products are being created by regional Fire Consortium for the Advanced Modeling of Meteorology and Smoke (FCAMMS). The FCAMMS are nationally coordinated through the U.S. Forest Service.

Continuous operation of this modeling framework allows researchers to identify gaps in knowledge of fuel condition, combustion, fire behavior, emissions, and dispersion.

The framework also allows sensitivity testing to help prioritize efforts needed to improve the science.

While other projects are being conducted to understand and predict smoke movement, this is the only effort that integrates *all* elements of the fire environment into a single modeling framework. Furthermore, it is the only undertaking that considers the day-to-day accumulation of impacts from multiple sources.

Project Identifier **: 01.PNW.A.1, Pacific Northwest Research Station.**

Lead Scientist: **Brian Potter, bpotter@fs.fed.us, 206-732-7828. (Lead Scientist was formerly the late Sue Ferguson.)**

BlueSky Real-time Air Pollution Prediction System Earns the 2004 National Fire Plan Award

…A considerable advancement in fire science.

BlueSky and its Rapid Access Information System (RAINS) are changing the way fire and smoke are managed. Since the project began in 2001, BlueSkyRAINS has helped land managers make quantitative decisions about smoke impacts and assisted operations on dozens of wildfires and hundreds of prescribed fires across the Northwest and Canada—fires that affected thousands of lives.

By working directly with users, the BlueSky team has helped incident commanders employ BlueSkyRAINS for aircraft resource allocation, timing of burnouts, and public information. The team integrated BlueSkyRAINS into fuel and smoke management programs and helped States, Tribes, and local air agencies improve and adapt the system for regulatory applications.

The BlueSky project has made significant progress in three of four goals of the National Fire Plan *10-Year Comprehensive Strategy*:

- ***Improve Prevention and Suppression*** by providing high-resolution weather and smoke predictions in GIS format to indicate location and timing of potential impacts well before dangers develop and in time to plan effective operations.
- ***Reduce Hazardous Fuel*** by providing quantitative predictions for burn decisions, thus promoting collaboration between burners and regulators and allowing prescribed burns to occur more often, more efficiently, and more safely.
- ***Promote Community Assistance*** by providing a publicly available graphic communication tool that clearly shows smoke impacts on sensitive receptors and community values.

BlueSky was developed by the AirFIRE team of the Pacific Northwest Research Station through collaboration with a consortium of members from the Environmental Protection Agency, Bureau of Land Management, National Park Service, U.S. Fish and Wildlife Service, U.S. Forest Service, and several States and Tribes. These members continue to meet regularly to evaluate progress and discuss future direction. The consortium includes several committees on state-of-the-science, technology transfer, liaison with related projects, and user needs.

By working directly with users, the BlueSky team has helped incident commanders employ BlueSkyRAINS for aircraft resource allocation, timing of burnouts, and public information.

Currently, BlueSky is available in every region through the Fire Consortia for Advanced Modeling of Meteorology and Smoke (FCAMMS). Administration-level negotiations are now underway to implement BlueSkyRAINS nationally.

BlueSky's integrative modeling framework and centralized processing have created a platform for rapid implementation of new science. Object-oriented programming allows components of fuel structure, fire behavior, consumption, emissions, dispersion, and weather to be quickly integrated, analyzed, and improved. Future development will allow "ensemble" predictions that employ all available fire tools.

Ensembles allow estimates of impact probability and uncertainty from a range of deterministic answers—representing a considerable advancement in fire science.

2. Multidisciplinary approach improves fire behavior prediction in New Jersey's volatile fuel type

Implementing Regional Climate and Fire Danger Modeling for the New Jersey Pine Barrens

Background

New Jersey fire managers have identified a top priority need for a reliable fire danger rating system for their region. While the National Fire Danger Rating System (NFDRS) works well in western forest ecosystems, it does not meet wildfire manager needs in this eastern region of the United States.

The 1.1 million acres of Pine Barrens—dominated by pitch pine, mixed oak species, and understory shrubs—represents 22 percent of New Jersey's land area. It is a highly volatile fuel type with a short fire return cycle—compared with fuels in most other eastern forests. An improved fire danger rating system would enable fire managers to strategically and cost effectively place firefighters and machinery in response to fires.

New Jersey towers located in (from left) oak/pine (leaf off), pine/oak, and pitch pine/scrub oak sites with instrumentation to measure: fire weather, fluxes of turbulence, energy, water vapor, and carbon dioxide. Photos: U.S. Forest Service.

Approach

A multidisciplinary approach is being taken to improve the existing fuel model. This includes:

- Enhancing the fire weather monitoring for the region,
- Analysis of historic fire climate records,
- Sensitivity analysis and modeling of component indices in the National Fire Danger Rating System, and
- Experimental monitoring of prescribed burns over a range of climate and humidity conditions.

Project Identifier **: 02.NES.A.1, Northeastern Research Station.** Lead Scientist: **Jon Hom, jhom@fs.fed.us, 610-557-4097.**

Products and Tools

This project's scientists have coordinated with New Jersey Forest Fire Service and the New Jersey state climatologist to establish a network of fire weather stations within the pine barrens. Seven fire weather towers (4 above canopy, 3 understory) are now maintained—with complete standard meteorological and fire weather instrumentation—in the northern pinelands of New Jersey.

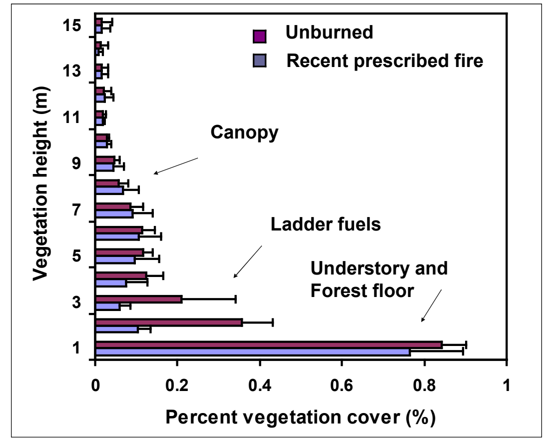
An improved fire danger rating system would enable fire managers to strategically and cost effectively place firefighters and machinery in response to fires.

Three of the above-canopy towers are instrumented to measure fluxes of turbulence, energy, water vapor and carbon dioxide (see photos). Parallel studies are being conducted in central Florida and in the Long Island fire cycle vegetation for refining the NFDRS to other areas of the United States.

Application for Management

This network of fire weather stations in the pine barrens provides real-time fire weather data access to regional fire managers by Internet using the New Jersey Weather and Climate Network (NJWxNet, http://climate.rutgers.edu/njwxnet/). To support fire managers in this region, the Eastern Area Modeling Consortium is providing daily high resolution fire weather modeling (MM5 @ 1 and 4 km^2) that predicts fire weather conditions 48 hours in advance (http://www.ncrs.fs.fed.us/eamc/products/maps.asp).

In addition, scientists are classifying and quantifying regional fuel loads through the use of LIDAR, as well as the use of forest inventory and biomass fuel loading plots. LIDAR data is also being used to detect the presence of ladder fuels, which increase the probability of understory fires becoming crown fires (see figure).



Percent vegetation cover and vegetation height estimated from LIDAR measurements near Cedar Bridge fire tower. The recently burned area was the site of a prescribed fire 2 months previously. The unburned site has not burned since 1995. Data are binned in 1 meter increments, ± 1 SD.

Collectively, these data are being integrated into GIS layers to produce high-resolution maps of forest structure and fuel loading across the pinelands. These maps will help in prioritizing hazardous fuel reduction.

Analysis of long term (1930-present) weather records and wildfire history data indicates that wildfire occurrence in this region is largely decoupled from fire severity indices such as the KBDI and Buildup Index, commonly used by New Jersey fire managers. This project's sensitivity analysis of the fire indices will provide better decision support tools for predicting fire danger.

The Pine Barrens has relatively flat topography, which, when combined with the new infrastructure network of towers, meteorological stations, and plots, presents a "model forest" system for validating fire models, remote sensing fuel loads, refining mesoscale weather models, and addressing regional air pollution and smoke emissions issues.

By addressing New Jersey's priority for an improved fire danger rating system in the Pine Barrens, we will establish a framework for improving fire weather monitoring and fire danger modeling that can be applied in the other parts of the United States.

3. Helping managers devise effective strategies for managing fire and fuels for wilderness and adjacent lands

Identifying the Benefits and Risks of Fire Improves Planning

Current Federal Wildland Fire Policy encourages wildland fire use (WFU) for restoring natural fire dynamics and reducing hazardous wildland fuel. Unroaded areas provide unique opportunities for applying WFU as a fuel management strategy and as a method for restoring the natural process of fire.

In many wilderness and other unroaded areas, however, vegetation conditions may preclude WFU because of excessive risks to natural resource values within the wilderness or to social values in the adjacent wildland-urban interface (WUI). In some areas, especially small wilderness areas with extensive WUI lands, WFU might never be feasible.

Even in larger unroaded areas, the argument will always exist to suppress some natural ignitions because of these risks. Finally, ignitions outside of these areas that otherwise would migrate into wilderness are usually suppressed—further limiting the amount of natural fire that can occur.

Therefore, before investing limited time and resources in developing and implementing a fire management plan, wildland fire and fuels managers can benefit from information and tools to help them evaluate the feasibility of WFU as a fuel reduction strategy and as a method for the restoration of fire.

Project Goals and Objectives

This project—funded, in part, through the Joint Fire Sciences Program—developed an approach to assess the feasibility and effectiveness of WFU as a strategy for restoring the process of fire and managing fuels in wilderness and other unroaded lands. The information generated by this research will help managers evaluate management objectives.

Under this project, scientists developed methods for evaluating effects that fire suppression on one side of an administrative boundary might have on the other side of that boundary. They used these methods to evaluate how suppression of lightning-caused ignitions that occur outside WFU zones might affect the ability to achieve the restoration of fire inside the WFU zones.

Specifically, scientists examined how eliminating the importation of fires that start on adjacent lands affects the predicted rate of burning for the WFU zone. Five wilderness areas and national parks (see next page), were assessed to determine the availability of natural ignitions to determine the degree to which suppression of natural ignitions outside WFU zones might hinder objectives to manage natural fire regimes.

This information can help with prevention planning, prioritizing fuel treatments, and anticipating where to expect the greatest conflicts with other management objectives when implementing a WFU program.

A secondary objective was to evaluate the risks and opportunities from WFU fires. This project's researchers assessed the risk and opportunity that lightning ignitions from the WFU zone might pose to different values of interest within the study areas. They evaluated risks to areas such as the WUI and ecologically sensitive areas, and evaluated expected benefits to areas that are inhabited by fire-dependent species. This information can help with prevention planning, prioritizing fuel treatments, and anticipating where to expect the greatest conflicts with other management objectives when implementing a WFU program.

Furthermore, scientists developed and demonstrated their approach using multiple-study areas that have very different precipitation regimes. As such, the approach developed is a robust one that can integrate information on summer precipitation patterns as well as patterns of season length over elevation.

Five study areas were selected that are managed primarily as wilderness: the Selway-Bitterroot Wilderness in Idaho and Montana, Gila-Aldo Leopold Wilderness Complex in New Mexico, Yosemite and Sequoia-Kings Canyon National Parks in California, and Great Smoky Mountains National Park in Tennessee and North Carolina.

These study areas were selected for several reasons including: availability of fire history information and other data required for this project's analyses, local expertise and established fire use programs, and for prior collaborative relationships that this project's scientists had with managers. All of the study areas had approved fire management plans with designated WFU zones.

This project directly addresses the research needs in Task 1 as described in the Joint Fire Science Program's Request for Proposals to:

"…evaluate the impacts of alternative management strategies" (specifically WFU) "on fire regimes in unroaded areas, wilderness areas, and other areas managed for similar purposes."

To accomplish project objectives, scientists used a GIS model, BurnPro, and the knowledge and experience of managers in each of their study areas.

Results

For the WFU zones identified in fire management plans, scientists estimated the probability of burning based on all natural ignitions in the study area. Ignitions falling outside of approved WFU zones were removed from the analysis and the probability of burning was recomputed.

From these analyses, the effect of eliminating the importation of fires that start on adjacent lands was quantified. To improve assessments of risks and benefits, scientists also combined the information on probability of burning with information on resource values.

Identifying Risks and Opportunities

In addition to evaluating fire management plans, this project's researchers took a more direct look at some of the risks and opportunities of WFU. These analyses varied among the study areas according to values-at-risk for each site and to site-specific requests.

Estimates of average annual probability of burning were overlaid with several values-at-risk to improve risk assessments. The estimates of probability of burning were also examined to determine where the greatest opportunities for WFU are located. By overlaying their estimates with values-to-benefit, scientists identified where WFU is most likely to benefit specific resources.

How is This Information Being Applied?

Through this project, estimates of probability of burning are being used to improve the prioritization of fire and resource management activities in several ways.

For example, in Yosemite National Park, areas with high probability of burning will be prioritized for archeological surveys—areas where cultural and scientific values may be at high risk.

In areas managed primarily for wilderness values, the probability of burning can be viewed in terms of opportunities to allow the natural process of fire to operate. High probabilities indicate where WFU opportunities are relatively common or frequent, while low probabilities indicate where opportunities are relatively rare.

This significant information is useful for fire management planning and supporting the go/no-go decision.

Project Identifier: **Miller, 01.RMS.A.5,**
Rocky Mountain Research Station.
Lead Scientist: **Carol Miller, cmiller04@fs.fed.us, 406-542-4198.**

Dr. Carol Miller Earns 2004 National Fire Plan Excellence in Research Award

Dr. Carol Miller's 2004 National Fire Plan (NFP) Excellence in Research Award was based on her success in creating an interdisciplinary research program that proactively addresses high priority fire and fuel management needs that directly align with the NFP core principles of collaboration, priority setting, and promotion of accountability.

Dr. Miller's collaborative research program is truly impressive. Over just the past three years, 18 of her 19 NFP studies were collaboratively developed with four universities (Idaho, Montana, Arizona, and Montana State), and 40 different National Forest and National Park Service units, including 17 Fire Management Units.

As an ecologist with a strong ecological modeling background, Dr. Miller has collaborated with social scientists to develop a new and deeper understanding of the social dynamics that strongly affect wildland fire and fuel management. To develop this collaborative network, Dr. Miller has effectively leveraged limited NFP funds to significantly expand this program.

Dr. Miller's research program is building a solid foundation of understanding about how fire and fuels vary over long timeframes and across landscapes. She and her staff designed and built two decision support tools: BurnPro, which allows managers to analyze where fire is most likely to occur, and the Fire Effects Planning Framework (FEPF), which allows managers to anticipate the potential consequences of fire and continued fire suppression to ecological and socio-economic values. Both tools were developed in collaboration with managers, utilizing local knowledge.

Both BurnPro and FEPF significantly help managers document how decisions are made and then communicate with the public about different options and consequences. Dr. Miller's research program combines ecological and social science to understand the needs of fire managers in fulfilling all four goals of the NFP:

- **Improving prevention and suppression**. Both BurnPro and FEPF help managers avoid using suppression resources on fires that pose little or no risk, thus significantly improving preparedness planning.
- **Reduce hazardous fuel**. By identifying areas most likely to burn in a wildfire, BurnPro provides critical information for prioritizing fuel reduction. FEPF identifies where values are at greatest risk from accumulated hazardous fuel and is being used by the Bitterroot and Sierra national forests to prioritize and plan fuel reduction projects.
- **Restore fire-adapted ecosystems**. BurnPro, while still under development, is being used in three national parks (Sequoia-Kings Canyon, Yosemite, and Great Smoky Mountains) and two Forest Service wilderness areas (Selway-Bitterroot and Gila) to evaluate and revise fire management plans that aim to restore healthy, diverse, and resilient ecological systems. BurnPro is also being used to help understand the role of indigenous cultures and their use of fire in creating these landscapes.
- **Promote community assistance**. Dr. Miller's work has already greatly increased local capacity to accomplish hazardous fuel reduction by developing tools that build upon existing data and use software that is already familiar to fire managers. Outside of this, these tools are recognized for their value in communicating options and consequences to the public. Dr. Miller's research program is a true "success story," showing a profound commitment to and success in improving the proactive management of fire and fuels.

Carol Miller (center) receives the 2004 National Fire Plan Excellence in Research Award from Dave Tenny, Deputy Undersecretary for Natural Resources and the Environment, U.S. Department of Agriculture; and Rebecca Watson, Assistant Secretary for Land and Minerals Management, U.S. Department of the Interior.

4. Linking weather conditions and fire occurrence to better predict continental-scale trends

Where should we locate our firefighting resources? And where will fuel reduction activities be most effective? To answer these questions, better predictions of fire risks and fire impacts across the United States are needed.

In this research project, scientists are therefore producing maps that link weather conditions and fire occurrence since 1895. They are using this information to develop 3- to 12-month fire forecasts.

These short-range predictions will allow agencies to better anticipate firefighting needs, thereby increasing fire preparedness. Ideally, forecasts of fire risks would project out for two to three years. But even a few months' warning is helpful to our land and fire managers.

Culprit: Climate Variability

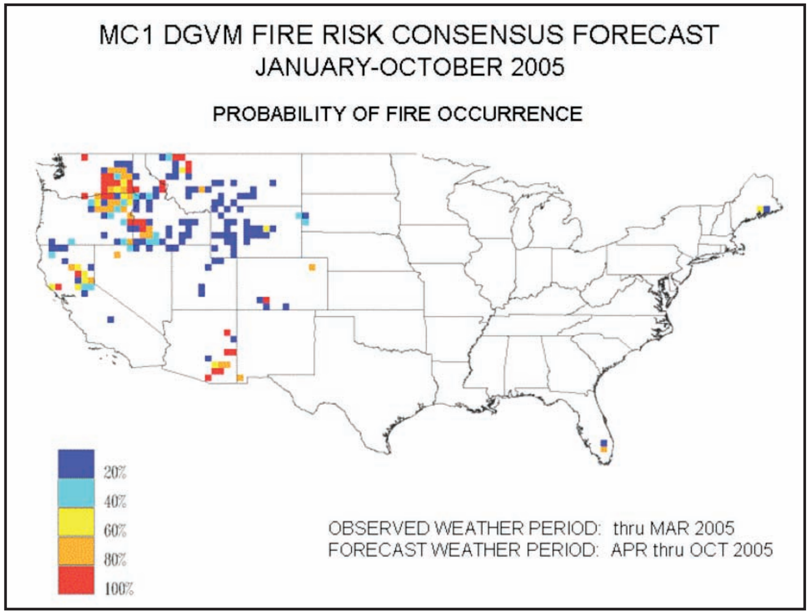
Increased fuel loads—from a century of fire exclusion—have traditionally been attributed to this country's recent large fires. However, climate variability is now increasingly considered to have had a large role in these recent fire patterns.

Thus, to understand the present fire situation and how to prepare for both the near- and the long-term future, fire forecasts must be balanced by historical analyses of fire/climate interactions.

Following two interdecadal wet/dry cycles since the mid-1970s, fire areas in the West have been strongly related to the Palmer Drought Severity Index (PDSI).

Recent climate variations are related to El-Niño/La-Niña cycles and various oceanic interdecadal oscillations that produced climate regime shifts in the mid-1940s, 1970s, and from 1988 through 1989. The West is currently in one of the worst droughts of the century—following fuel buildup during strong wet cycles.

This weather pattern appears to have fostered much of this country's recent severe fires.



The project's MC1 model demonstrated a highly significant correlation between observed vs. simulated trends in total annual area burned in the United States from 1960 to 2002. The observed area burned is an order of magnitude less than the simulated area, owing to fire suppression and other land use effects—not yet accounted for in the model. An ocean atmosphere climate regime shift occurred in 1988-89 and demonstrates that the recent increase in fire area is clearly related to climate.

Observations Date Back to 1895

In this study, retrospective analyses are made possible through gridded weather observations that date back from 1895 to today's most recent month. Simulations of the past century also are required for the model to estimate current fuel loading and fuel condition—albeit without fire suppression included in the model.

The model shows good accuracy in simulating the spatial and temporal distributions of observed fire activity during the last four decades across the United States—even without accounting for fire suppression.

This study's researchers have determined that while both observed and simulated fire areas over the United States declined slightly from 1960 to 1988, they have increased dramatically since then.

Forecasts for the 2004 and 2005 fire seasons were updated monthly, based on three six-month coupled ocean-atmosphere/climate model forecasts. Observed fire activity was remarkably coincidental with the simulated distribution of fire risk.

Products and Tools

The Mapped Atmosphere-Plant-Soil System (MAPSS) Team at the Pacific Northwest Research Station has developed one of two models in the world that can simulate most terrestrial ecosystem dynamics, including the location, timing, and impacts of wildfire.

Although originally developed for simulating potential climate change impacts, the "MC1"model is ideally suited for seasonal fire danger forecasting as well as for analyzing historical climate-fire interactions. To better anticipate firefighting and management needs, the team is publishing experimental six-month fire-risk forecasts onto a Web site: http://www.fs.fed. us/pnw/corvallis/mdr/mapss/fireforecasts.htm.

Application

The forecasts and historical analyses are being used in briefings to the USDA Undersecretary for Natural Resources and Congress and for the Quadrennial Fire Review for understanding the recent historical and possible future fire patterns.

Because the seasonal forecasts are relatively new and experimental, their use on the ground is only now being explored.

Ron Neilson Receives USDA Secretary's Honor Award for Superior Research and Volunteerism

Ron Neilson, a bioclimatologist at the Pacific Northwest Research Station's Corvallis Forestry Sciences Laboratory—and lead scientist for this National Fire Plan Research and Development project—was awarded the USDA Secretary's Honor Award. This award recognizes superior research and volunteerism.

Neilson received the award from USDA Agriculture Secretary Ann Veneman for his efforts in "maintaining and enhancing the nation's natural resources and environment, and for his contributions to understanding the potential impacts to ecosystems, water resources, and fire regimes under climate change at the regional, national, and global scales."

Project Identifier: **01.PNW.A.3, Pacific Northwest Research Station.**

Lead Scientist: **Ronald P. Neilson, rneilson@fs.fed.us, 541-750-7303.**

5. Providing real-time fire monitoring nationwide to improve fire attack strategies and resource allocation decisions

Daily intelligence on fire locations and burned areas is currently compiled from ground surveys and is not reported until the following day. Under this project, scientists are therefore working on a nationwide fire monitoring system that will allow reporting of data with only a 2–4 hour delay.

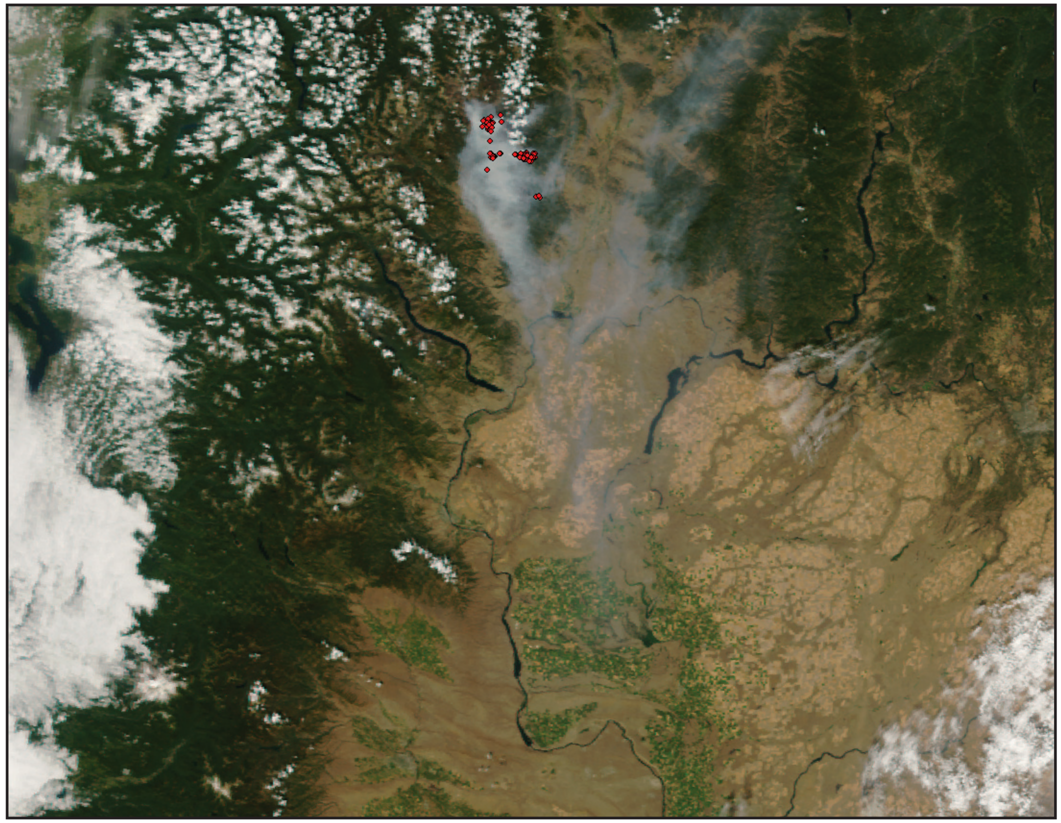
This is accomplished by using satellite data to monitor several factors, including:

- Active fires,
- Fire severity, and
- Smoke concentrations and dispersions.

Such real-time fire information is now better assisting fire managers in developing fire attack strategies and making resource allocation decisions.

Project Accomplishments

In working on this project, scientists have developed a new algorithm for mapping burn scars of large fires in real-time using Terra and Aqua satellite data. This information has been developed in conjunction with colleagues at NASA's Goddard Space Flight Center.



This project's researchers developed a new map production software package used to automate the formerly manual process of displaying satellite images and MODIS hotspots on a nationwide map.

The monitoring of burned areas is essential for determining the amount of fuel consumed and pollutants produced. (A manuscript detailing this work has been published by *IEEE Transactions on Geoscience and Remote Sensing*.)

Scientists have also carried out a series of field experiments to validate the aerosol levels—measured by the MODIS instrument on the Terra and Aqua satellites—during the Western Amazon and Thailand's fire seasons. (Researchers conducted these experiments in tropical countries to avoid the high cost of conducting such activities in the United States.)

In this country, during severe fire seasons in Montana and Idaho, researchers provided active fire locations and fire perimeters in near real-time twice every day to the Northern Rockies Multiagency Coordination Group. The daily nationwide fire maps that were generated were sent to the National Incident Information Center. They were also used as part of the Chief's briefing materials to the White House, Congress, and other Federal agencies on "next day" fire situations.

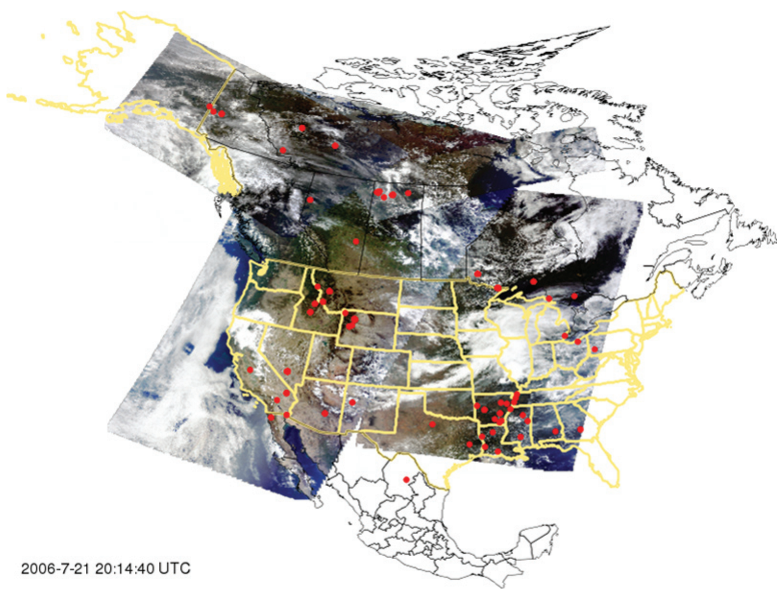
Improving the Process

The researchers' new map production software package is now being used to automate the formerly manual process of displaying satellite images and MODIS hotspots on a nationwide map (http://www.firelab.org). This map is updated as new data become available.

The software of fire behavior model *FARSITE* has also been "reengineered" to ingest real-time satellite-derived burn scars as starting points for fire spread projections.

One of this project's undertakings included a series of field experiments that were carried out to map fire radiative energy emitted from the 2005 Bull Fire in New Mexico's Black Range Complex of the Gila National Forest, as well as from several wildfires along Interstate I-90 in Missoula, MT.

Using this data, scientists were able to compare the fire radiative energy measured by the two radiometers with the fire radiative energy predicted by the plume rise model PLUMP.



Project Identifier:
Hao, 01.RMS.A.2,
Rocky Mountain Research Station.

Lead Scientist:
Wei Min Hao, whao@fs.fed.us, 406-329-4838.

6. Enabling managers to better anticipate fire risks in chaparral fuels

Even though wildfires occur in live vegetation, since the 1960s, little fundamental research has been performed to understand the dynamics of fire ignition and fire spread in live fuels. In addressing this, researchers are now conducting laboratory and field-based experiments to better understand and model combustion processes within these fuels. The findings and information from this research will help managers better anticipate fire risks.

Through various burning experiments, scientists have developed a database of 280 laboratory-scale experiments to examine the effects of environmental variables (wind speed, ambient temperature, relative humidity) and fuel characteristics (fuel type, moisture content, fuel loading, depth of fuel bed, slope/topography) on marginal burning in chaparral fuels.

These modeling efforts have been useful in understanding the relative roles of convective and radiation heat transfer effects on marginal burning behavior. Scientists have also completed a detailed experimental study that is focused on characterizing fire plumes over chaparral fuel.

In addition, they have initiated modeling and experimental studies for understanding the transition from ground to crown fires—an area about which researchers and land managers know very little about. Such an undertaking is therefore critical to gaining knowledge and insights into this wildland fire dynamic.

Enhancing Fire Spread Models

This project's scientists also studied how live fuel fire brands cause faster spread rates by two mechanisms:

1. Many brands land directly in front of the fire line. This is an unexplored mechanism of increasing the contiguous fire spread rate.

2. Lofted fire brands can initiate spot fires well ahead of the contiguous fire. This is a well-known phenomenon which must be quantified if prescribed burning is to become accepted as a safe fuel management tool.

Thus, the researchers' goal was to begin incorporating both of these mechanisms into their existing physics-based fire spread rate model. At the same time, they continued to develop the comparisons of this model and LANL's FIRETEC model with the laboratory fire spread data for live fuels from the University of California Riverside and the field fire spread data for live fuels from the University of California Berkeley.

These developments have enhanced FIRETEC as a research model for fire behavior.

Combustion Data Findings

Under this project, qualitative and quantitative combustion data were also obtained in a flat-flame burner facility to serve as representative samples of the four species representative of California chaparral (manzanita, scrub oak, ceanothus, and chamise), as well as the four Utah species (gambel oak, sagebrush, juniper, and bigleaf maple).

The ignition point was determined based on frame-by-frame analysis of video images and correlated with thermocouple readings.

Subsequent findings included that the moisture content varied—mainly due to the storage time in the lab. Average ignition temperatures of high moisture broadleaf samples were found to be as much as 120°C higher than ignition temperatures of corresponding low moisture samples.

At high moisture content, severe bubbling caused small craters in the surface of the manzanita leaves prior to ignition. Visual differences were also observed in the ignition behavior of the other two plant species.

Project Identifier: **01.PSW.A.3, Pacific Southwest Research Station.** Lead Scientist: **David R. Weise; dweise@fs.fed.us; 909-680-1543.**

Accomplishments

Rehabilitation and Restoration

In the aftermath of a wildland fire event, federal, state, and local agencies strive to:

- ❖ Maintain the quality of water;
- ❖ Minimize the negative impacts of accelerated runoff, erosion, and sedimentation; and
- ❖ Ensure optimal recovery of vegetation and ecosystems.

Results of the National Fire Plan Research and Development—as outlined in this section—are helping managers to:

- ❖ Apply appropriate and cost-effective restoration and post-fire rehabilitation treatments, and
- ❖ Develop improved procedures for monitoring treatment effects.

Thinning unit on the Apache-Sitgreaves Natinal Forest survives the severity of the Rodeo-Chediski Fire's flame front. Photo: Tom Iraci, U.S. Forest Service.

Characterizing the risks of wildfire and fuel management in aquatic systems

Significant resources are used to manage fire and fuel and to mitigate the effects of past fire suppression. At the same time, substantial resources have been invested in restoring watersheds and fostering recovery of sensitive species. Limited information on the effects of fires and fire-related management on aquatic systems makes it difficult to determine the benefits of the substantial costs that are incurred. Scientists in central Idaho are therefore working to quantify the influence of large fires, post-fire climatic events, and post-fire management on watershed processes and the persistence of sensitive aquatic species. Better understanding of when and where fire represents a threat to aquatic ecosystems will enhance managers' ability to characterize risk and prioritize fire and fuel management and post-fire rehabilitation efforts.

Project Identifier: **Rieman, 02.RMS.B.1, Rocky Mountain Research Station.**

Lead Scientist: **Bruce Rieman, brieman@fs.fed.us, 208-373-4386.**

Diseased dead and dying stand on Oregon's Deschutes National Forest. Photo: Tom Iraci, U.S. Forest Service.

Developing techniques to prevent weedy species invasions that increase fire size, frequency

Researchers are looking at the effectiveness of tools—such as prescribed fire—to restore and sustain native grasslands, and to help reduce the incursion of woody plants. A study was completed by using calorimetry to document population differences in important shrub species and biological soil crusts. The study documented the physiological differences in optimal growth temperatures of southern and northern collections—refining significant information for restoration work efforts.

Project Identifier:
Finch, 01.RMS.B.7, Rocky Mountain Research Station.

Lead Scientist:
Deborah Finch, dfinch@fs.fed.us, 505-724-3671.

Fire exhibits intensity at night. Photo: Tom Iraci, U.S. Forest Service.

Improving our ability to estimate post-fire risks of flooding, soil erosion, and drinking water contamination

Increases in post-fire nutrient loading (especially nitrate) on water quality are of concern across all landscapes. In the past, several watershed models have been developed to predict runoff and sediment yield, but little effort has been directed specifically toward modeling the effects of wildfire and prescribed fire on forest hydrology. Researchers are therefore testing and applying nutrient cycling and hydrology models (NuCM and MIKE-SHE) to determine their effectiveness in predicting impacts of fire on hydrological, nutrient cycling, and soil erosion processes. Results will improve managers' ability to estimate post-fire risks of flooding, severe soil erosion, and contamination of drinking water.

Project Identifier: **Vose, 02.SRS.B.1, Southern Research Station.**
Lead Scientist: **James M. Vose, jvose@fs.fed.us, 828-524-2128.**

Researchers incorporating predictive post-fire models to help protect native fish and human health and safety

The huge and high-severity wildfires being experienced in the southwest now pose the greatest threat—than in the past 10,000 years—to native and Threatened and Endangered fish in this part of the country. After fires are extinguished, post wildfire peak flood flows become the major threat to watershed resources, cultural resources, and human health and safety. Information on waterflow patterns and the geology of sites is critical for assessing the risks of post-fire erosion and flooding. Researchers are working to incorporate these factors into predictive models that will provide managers with better support for burned area emergency rehabilitation decisions. The past three years, information has been collected on the native fish population impacts from seven Arizona and New Mexico wildfires where post-wildfire floods have the potential to eliminate 80 to 100% of both native and non-native fish populations.

Project Identifier: **Neary, 01.RMS.B.1, Rocky Mountain Research Station.** Lead Scientist: **Daniel G. Neary, dneary@fs.fed.us, 928-556-2176.**

BAER Team-directed fire rehabilitation activities in the wildland-urban interface on the Coronado National Forest following the 2003 Bullock Fire. Photos: Tom Iraci, U.S. Forest Service.

Ensuring the correct native seed supplies are available to land managers for burned area restoration

Management objectives increasingly require burned areas to be restored using native plant species. The availability of these species, however, is low. Furthermore, little information is available on what native species would work best on specific burn areas. Scientists are therefore working on identifying and characterizing native species' potential for use and are also developing practices for seed production and protocols for seed warehousing. This effort will help ensure native seed supplies are available to land management agencies.

Project Identifier: **McArthur, 01.RMS.B.2, Rocky Mountain Research Station.**

Lead Scientist: **E. Durant McArthur, dmcarthur@fs.fed.us, 801-356-5112.**

Understanding the ecological, economic, and social consequences of wildfire and rehabilitation on forest health

Wildfire, fuel reduction, and thinning treatments create conditions that encourage the establishment of weed species and may even increase the susceptibility of trees to diseases. Interdisciplinary research is now being targeted to understand the ecological, economic, and social consequences of wildfire and rehabilitation efforts on southwestern forest health. This information will be used in developing guidelines for post-fire vegetation management.

Project Identifier: **Clancy, 01.RMS.B.4, Rocky Mountain Research Station.**

Lead Scientist: **Karen Clancy, kclancy@fs.fed.us, 928-556-2105.**

Highlight Projects

Rehabilitation and Restoration Accomplishments

1. Measuring the effectiveness of post-fire emergency rehabilitation to help managers select effective treatments

Because the effectiveness of many of these rehab methods has never been tested quantitatively, it is difficult for BAER teams to realistically assess the short- and long-term benefits.

While expenditures for post-fire rehabilitation—including contour-felled logs, surface raking, and native grass seeding—have increased dramatically in recent years, little quantitative information exists on the effectiveness of these treatments in reducing sediment movement and water output from burned areas.

Researchers involved in this project are therefore initiating studies to measure runoff and sediment production from watersheds that are receiving various emergency rehabilitation treatments. This information will help managers select future emergency treatments that are most likely to be effective.

Investigating Treatment Effectiveness

Each year, after wildfire, millions of dollars are spent on emergency stabilization and rehabilitation treatments to protect life, property, and natural resources from increased erosion and flooding. Yet, because the effectiveness of many of these rehabilitation methods has never been tested quantitatively, it is difficult for Burned Area Emergency Rehabilitation (BAER) teams to realistically assess the short- and long-term benefits of their prescribed treatments relative to their economic and ecological costs.

As part of this research project, in Fiscal Year 2005, a new site on the Umatilla National Forest was established to investigate the effectiveness of two mulch treatments, including wood "straw" and native grass seeding. Because it does not contain potential weed seeds, wood straw may have advantages over wheat or rice straw.

This project's scientists also helped the southern California national forests continue their BAER effectiveness monitoring of the fall 2003 southern California large fires. As part of this project, data from the research study on the Cedar Fire (fall 2003, examining effectiveness of aerial hydromulch) were written up for the Capitan Grande Indian Tribe.

Preliminary Results

In Fiscal Year 2005 this project's scientists continued measurements at various study sites to test the effectiveness of contour-felled logs—a popular but expensive treatment for reducing post-fire runoff and sedimentation. They also examined the efficiency of various mulch treatments.

Associated efforts are currently underway for various post-fire rehabilitation treatments, including:

- Analyzing collected data,
- Developing treatment guidelines, and
- Refining site application criteria.

Preliminary results suggest that rainfall intensity is one of the most important drivers for the erosion response. In addition, mulch treatments are performing better than barrier-type treatments (log erosion barriers, straw wattles, contour-felled logs). Mulch treatment functionality, however, is governed by rainfall characteristics. Annual recovery of sites demonstrate a marked decrease in erosion, except for those sites influenced by monsoon climates—where recovery generally takes longer.

The addition of a new study site and continued accumulation of data from existing sites have resulted in numerous technology transfer opportunities. This project's team members provided presentations on this work to both scientific and management groups.

Project Identifier: **01.PSW.B.1, Pacific Southwest Research Station.**
Lead Scientists: **Jan Beyers, jbeyers@fs.fed.us, 909-680-1527; Pete Robichaud, probichaud@fs.fed.us, 208-883-2349**.

2. Developing management techniques to prevent weedy species invasions that increase fire size, frequency

The proliferation of fire-adapted invasive species, such as cheatgrass in the Great Basin, is negatively impacting ecosystems by increasing fire frequency, intensity, and size.

Under this project, factors that make ecosystems particularly susceptible to these "invasions" were examined. Researchers developed improved equations for determining fuel loads for Great Basin woodland trees. In Joint Fire Sciences Program-funded measurement plots used to demonstrate fuel treatments, fuel loads for these trees were determined.

Because ecosystem susceptibility to invasion by nonnative species is poorly understood, data and findings from this research are helping to determine how several interacting factors—including climate, disturbance regime, and the competitive abilities of resident species—are making Great Basin sagebrush ecosystems so susceptible to invasive species such as cheatgrass.

This project's lead scientist, Jeanne C. Chambers.

Significant Research Accomplishments

This research project included a special course taught by the project's lead scientist, Jeanne C. Chambers, and Robin Tausch at the University of Nevada, Reno, NV. The course was entitled "*Effects of Fire on Great Basin Ecosystems*."

Scientists involved in this project also presented special field trips to their demonstration watershed and invasive species study areas for land managers and other researchers, as well as for the general public.

Under this project, scientists have successfully developed:

- Protocols for determining *when* prescribed fire can be implemented *without* risk of conversion to invasive plants.
- Improved equations for determining fuel loads for Great Basin woodland trees—including fuel loads for trees in Joint Fire Science demonstration area plots.
- Techniques and a devise for safely conducting small plot burns in Great Basin shrub and woodlands.

Project Identifier: **01.RMS.B.5, Rocky Mountain Research Station.**

Lead Scientist: **Jeanne C. Chambers, jchambers@fs.fed.us, 775-784-5329.**

3. Researchers providing managers with improved information on choosing alternative vegetation treatments

Unfortunately, efforts to reduce fuel amounts *before* fires, and to restore vegetation *after* fires, can encourage the spread of weeds. These weeds then crowd-out native plants and negatively impact ecosystems.

Therefore, researchers are now providing managers with improved information on the relative risks of choosing alternative vegetation treatments. They are monitoring the effects of fuel reduction and restoration treatments on the spread of weeds. They have adapted and developed landscape invasive plant sampling methods in Oregon's upper Grande Ronde River basin study area.

In performing this new study, researchers also discovered a major, previously undetected landscape-scale invasive plant infestation, *Ventenata dubia*—or, north Africa grass. Thus, a new study of *V. dubia* has been initiated in cooperation with the Wallowa-Whitman National Forest.

Significant Research Accomplishments

This project's scientists have:

- Completed syntheses of available literature on ecology and relationships of invasive plant species to disturbances (including fire) and management practices in the Pacific Northwest. This vital information was utilized by the Forest Service's Pacific Northwest Region in preparing the region's draft invasive species Environmental Impact Statement.
- Continued the development of Invasive Species Risk Assessment protocols for use by land managers in designing fuel reduction and other fire management practices from stand to landscape scales.
- Developed and refined forest growth transitions using the Forest Vegetation Simulator—including the effects of large ungulate herbivory (deer, elk, cattle).
- Initiated the refinement of invasive plant modules based on information from field studies in Oregon's upper Grande Ronde River Basin.
- Completed a study on the comparative and competitive pollination biology of native vs. naturalized *Potentilla* species and associated rare native plants in Idaho and Oregon. Studies were also completed on the age structure and seed dispersal biology of *Potentilla recta* populations in eastern Oregon. Outcomes of these studies are helping to determine the differential responses of invasive and native plants in the aftermath of fire and other disturbances.
- Developed detection and monitoring approaches for invasive plant species in fire-prone ecosystems by completing a key for the identification and characterization of common *Potentilla* species in eastern Oregon that are enabling land managers to more accurately detect this genus (which includes several key invasive species).
- Increased the fundamental understanding of the biology and ecology of key invasive plant species in fire-prone

"The outcomes of these studies will shed light on causes for differential responses of invasive and native plants in the aftermath of fire and other disturbances."

"Findings from this research indicate that spring prescribed burning may be preferable to fall burning from a non-native species invasion standpoint."

ecosystems. Specifically, particular progress has been made on a series of eastern Oregon studies on the biology, ecology, and management of sulfur cinquefoil (*Potentilla recta*)—an invasive species of increasing regional concern. Studies on aging, population age distribution and reproductive dynamics (seed production and dispersal) of sulfur cinquefoil, have been completed and published. Outcomes from this important research will now prove useful in predicting population characteristics of this species following wildfire and fuel reduction treatments.

- ❖ Increased the understanding of responses of key invasive plant species to fire, fuel/vegetation management and other associated disturbances. Preliminary analyses of findings from a retrospective study of a time-series of antecedent fuel reduction treatments (thinning, prescribed burning, and thinning+burning) are elucidating the effects of these treatments on invasive plant species in eastern Washington. Under this research, the combining of burning and thinning to reduce fuels has been found to significantly increase cover and richness of invasive plants—whereas burning and thinning alone had a negligible effect on non-native species. However, no fuel reduction treatment significantly changed native understory species cover or richness. Results also suggest that increasing the size (acreage) of individual prescribed burning projects also increased the resultant cover of invasive understory plant species.
- ❖ Published the outcomes of related work on relationships among the timing of prescribed fire, livestock grazing, and invasive plant species in eastern Oregon. These findings indicate that spring prescribed burning may be preferable to fall burning from a non-native species invasion standpoint. Findings also suggest that the synergistic effects of prescribed fire and livestock grazing decreased cover/growth of perennial native plant species while stimulating short-lived exotic and native species. These and other findings will now help to inform the development of fuel and vegetation management practices that address invasive plant species concerns in the interior northwest and elsewhere—as well as enhance the restoration of these ecosystems impacted by invasive plants.

Project Identifier: **01.PNW.B.1, Pacific Northwest Research Station.**

Lead Scientist: **Edward J. DePuit, ejdepuit@fs.fed.us, 509-664-1715.**

Accomplishments

Hazardous Fuel Reduction

A National Fire Plan key focus is the successful management of forest and rangeland fuels to reduce fire risk to communities and fire damage to ecosystems.

As this section illustrates, National Fire Plan Research and Development on hazardous fuel reduction is helping managers:

- Set priorities,
- Determine appropriate treatment regimes, and
- Balance the often complex tradeoffs between the benefits of managing fuel to reduce fire intensity and severity—and the possible social, environmental, and ecological impacts of mechanical and prescribed fire treatments.

Rehabilitation site on Santa Fe National Forest two years after the Cerro Grande Fire. Photo: Tom Iraci, U.S. Forest Service.

Achieving fuel reduction goals and restoring riparian zones to healthy conditions

Due to the absence of flooding and fire, many stream ecosystems throughout the Rocky Mountains are undergoing vegetation changes. This is reducing the potential for these sites to house a variety of threatened, endangered and state-listed species. Researchers are measuring populations of these animals and their critical habitat in burned and unburned riparian areas in Montana and New Mexico. Their results will supply guidance for restoring riparian zones to healthy conditions while simultaneously achieving fuel reduction goals.

Project Identifier: **Finch, 01.RMS.C.8, Rocky Mountain Research Station.**

Lead Scientist: **Deborah Finch, dfinch@fs.fed.us, 505-724-3671.**

Determining fuel reduction effects on sensitive riparian zones

While we have quite a bit of information on wildfire effects, little information exists on the effects of prescribed fire on stream ecosystems. The use of prescribed fire in riparian areas is currently being debated in the Sierra Nevada. Researchers will determine the magnitude and duration of effects from both prescribed fire and mechanical treatments on the physical, chemical, and biological components of forest stream ecosystems and their associated watersheds. Results from this study will help guide managers in selecting fuel reduction treatments best suited for these sensitive zones. This research is planned to continue for approximately 12 years. It started with baseline data collection in 2002, will require four years of baseline data collection, two years for fuel treatments, and five to seven years of post-treatment data collection.

Project Identifier: **Hunsaker, 01.PSW.C.1, Pacific Southwest Research Station.**

Lead Scientist: **Carolyn T. Hunsaker, chunsaker@fs.fed.us, 559-323-3211.**

Integrated research on fire and fuel management, landscape dynamics, and fish and wildlife resources

The January 2001 Record of Decision (*Sierra Nevada Forest Plan Amendment*) institutes a new forest management regime with the intent of balancing the positive and negative effects of fuel management on an array of ecological and socioeconomic values. Presently, however, there is inadequate scientific information on which to base projections of forest response under different management alternatives. Therefore, increased knowledge about effects of alternative landscape-level fuel treatment strategies is needed. Thus, under this research project, scientists' efforts are directed at evaluating the effects of the Herger Feinstein Quincy Library Group Pilot Project approach on:

1) California spotted owl and other wide-ranging species,
2) subsequent size and severity of wildfires, and
3) other large-scale ecosystem components and processes.

Project Identifier: **Stine, 02.PSW.C.1, Pacific Southwest Research Station.**

Lead Scientist: **Peter Stine, pstine@fs.fed.us, 530-759-1703.**

Management alternatives for fire-dependent ecosystems in Colorado and the Black Hills

Fire suppression and exclusion throughout the Central Rocky Mountains have resulted in conditions that make the risk of catastrophic fires likely to occur. Researchers are gathering information on the types and methods of fuel reduction alternatives best suited to treating these high fuel levels to restore a more natural mix of ecological conditions, simultaneously reintroducing fire as a management tool.

Project Identifier: **Joyce, 01.RMS.C.4, Rocky Mountain Research Station.** Lead Scientist: **Linda A. Joyce, ljoyce@fs.fed.us, 970-498-2560.**

Investigating the impacts of exotic weeds on fuel loadings and fire regimes on native sagebrush plains

The cycle of wildfires and annual weed invasion has altered millions of acres of western shrublands and grasslands by reducing plant and animal diversity and increasing fire size and frequency. Scientists are working on quantifying effects of weedy species on native sagebrush plains. Study results will provide managers with new tools and plant resources for reestablishing and protecting biological diversity.

Project Identifier: **Shaw, 01.RMS.C.1, Rocky Mountain Research Station.**

Lead Scientist: **Nancy L. Shaw, nshaw@fs.fed.us, 208-373-4360.**

Measuring the impacts of fuel management treatments on forest soil erosion and production

Soil erosion, soil compaction, soil productivity, and soil microbial processes perform a critical role in forest health. They can all be impacted by fuel management treatments. Scientists are investigating the effects of fuel management treatments—including thinning, salvage logging, and prescribed fire—on soil characteristics. The resulting information will be incorporated into computer models that can be used by managers to assist in fuel management decisions.

Project Identifier: **Eliot and Page-Dumroese, 01.RMS.C.3, Rocky Mountain Research Station.**

Lead Scientists: **William Elliot, welliot@fs.fed.us, 208-883-2338; Deborah Page-Dumroese, ddumroese@fs.fed.us, 208-883-2339.**

Combining fire and herbicide treatments to reduce fire intensity in high-risk areas

Most fuel reduction efforts in Florida's industrial forests—often located adjacent to wildland-urban interface areas—involve using herbicides. However, after herbicide application, a two-year time lag exists before fire danger is significantly reduced. Researchers are therefore examining the effectiveness of a treatment to reduce fuel buildup that combines prescribed fire *with* herbicide treatments. If effective, this new treatment regime could provide another option to managers for fuel reduction in these high-risk areas.

Project Identifier: **O'Brien, 01.SRS.C.5, Southern Research Station.**

Lead Scientist: **Joseph O'Brien; jjobrien@fs.fed.us; 706-559-4337.**

Severe effects on the 2003 wildland-urban interface Rodeo-Chediski Fire in the Southwestern Region. Photo: Tom Iraci, U.S. Forest Service.

An integrated system for managing fuel loads at the wildland-urban interface

In some areas, rapid human population growth and the increasing extent of wildland-urban interface have made the use of prescribed fire as a fuel reduction tool nearly impossible. In the South, researchers are developing an integrated system to manage fuel loads through mechanical means to treat "urban woodlands." This study will provide managers with fuel reduction techniques that are both effective and socially acceptable.

Project Identifier: **Stanturf, 01.SRS.C.4, Southern Research Station.**
Lead Scientist: **John Stanturf, jstanturf@fs.fed.us, 706-559-4316.**

Using spatial models to better understand fire suppression and fire regimes in the Great Lake region

Changing land uses and fire suppression during the past century have greatly altered the frequency, intensity, extent, and severity of fire on the landscape. Researchers are using spatial models to better understand the effects of past and current land uses, and of fire suppression on fire regimes in the Great Lakes Region. Results of this research will be used to develop guidelines for reducing fuel loads.

Project Identifier: **Palik, 01.NCS.C.1, North Central Research Station.** Lead Scientist: **Brian Palik, bpalik@fs.fed.us, 218-326-7100.**

Assessing and mitigating fire risk for landowners in the southern wildland-urban interface areas— and establishing a wildland-urban interface research and technology transfer unit for the south

This research examines multiple components of fuels as they relate to fire hazard for wildland-urban interface landowners. Specific projects address interface landscape characteristics and fire risk, flammability ratings of southern fuel, landowner risk assessment procedures, and fuel management options for landowners.

With the steady rise of new homes in southern forestlands, wildland firefighters and small forest land owners need information and technology to deal with the unique issues of preventing, fighting and mitigating fire in the wildland-urban interface. The Southern Research Station is establishing a center for fire prevention and pre-suppression information for federal, state, and local firefighting units in the South, especially those who work in the wildland-urban interface.

Project Identifier: **Macie, 01.SRS.A.3,**
Southern Research Station.
Lead Scientist: **Edward Macie,**
emacie@fs.fed.us, 404-347-1647.

Effects of wildland fire and fuel treatments on vertebrates

Many birds and mammals depend on wildland fire for some aspect of their life history. Within ponderosa pine systems, historical fire regimes resulted in shifting mosaics of burned and unburned areas across the landscape. Little is known, however, about animal and plant responses to wildfire, fire exclusion, or fuel management treatments designed to mimic pre-settlement conditions. Researchers are studying effects of wildfire and fuel treatments—prescribed fire and mechanical thinning used singly and in combination—on breeding and non-breeding birds and small mammals in the Intermountain West and Rocky Mountain Regions. This information will help land managers assess cumulative effects and evaluate ecological trade-offs when considering options for treating and managing fuels.

Project Identifier: **Block, 02.RMS.C.2,**
Rocky Mountain Research Station.
Lead Scientists: **William Block,**
wblock@fs.fed.us, 928-556-2161;
and Victoria Saab, vsaab@fs.fed.us, 406-994-5032.

BAER rehab project efforts on the Coronado National Forest's Bullock Fire area (left), and aspen rejuvenating on the Santa Fe National Forest's Cerro Grande post-fire area. Photos: Tom Iraci, U.S. Forest Service.

Restoring fire-dependent ecosystems in the northeast's previously oak-dominated forests

Previously oak-dominated forests in the northeast portion of the country are shifting to maple dominance due to fire suppression over many years. While prescribed fire and thinning treatments may restore oak dominance, information on fuel, fire behavior, and fire weather to guide these efforts in this region is lacking. An interdisciplinary team of scientists is therefore developing models to understand how fire and thinning can best be used to restore these fire-dependent ecosystems.

Project Identifier: **Dickinson, 01.NES.C.1, Northeastern Research Station.**
Lead Scientist: **Matthew Dickinson, mbdickinson@fs.fed.us, 740-368-0096.**

Examining the implications of forest vegetation structure on burn severity and succession after fire

Fuel management, forest growth, and forest health all interact to affect fire behavior. Researchers are studying these interactions to examine the implications of forest vegetation structure on burn severity and succession after fire. Information from these studies will be integrated into existing fire modeling systems that managers can use to develop fuel management treatments.

Project Identifier: **Ferguson, 01.RMS.C.2, Rocky Mountain Research Station.**
Lead Scientist: **Dennis E. Ferguson, deferguson@fs.fed.us, 208-883-2315.**

Researching the environmental and economic impacts of biomass reduction in the Northwest and Southeast

Reducing fuel buildups—with or without prescribed fire—may adversely impact the environment through: 1) increased erosion and runoff, 2) reduction in stored carbon and forest health, or 3) damage to remaining vegetation. Integrated information on the impacts of biomass reduction operations on soil, water, and forest health is sparse. Scientists are therefore carrying out a series of integrated interdisciplinary studies in the Northwest and Southeast on thinning operations impacts to reduce forest biomass levels on terrestrial and aquatic ecosystems. This information will help managers to both assess the impacts to ecosystems and select the appropriate fuel reduction alternative.

Project Identifier: **Elliot, 02.RMS.C.1,**
Rocky Mountain Research Station.

Lead Scientist: **William J. Elliot,**
welliot@fs.fed.us, 208-883-2338.

Determining the impacts of fuel management treatments on forest soil erosion and production

Soil erosion, soil compaction, soil productivity and soil microbial processes perform a critical role in forest health. All of these processes can be impacted by fuel management treatments. Scientists are therefore investigating the effects on soil characteristics from fuel management treatments such as thinning, salvage logging, and prescribed fire. The resulting information will be incorporated into computer models that can be used by managers to assist in fuel management decisions.

Project Identifier: **Elliot, 01.RMS.C.3,**
Rocky Mountain Research Station.

Lead Scientists: **William J. Elliot,**
welliot@fs.fed.us, 208-883-2338;
Deborah Page-Dumroese,
ddumroese@fs.fed.us, 208-883-2339.

Quantifying the ecological and economic tradeoffs of fire and its surrogate options in the Southern Appalachians

Rapidly growing urban/wildland interface areas of the Piedmont and Southern Appalachians are at risk from fire due to dangerous fuel buildups. Use of prescribed fire to reduce fuel levels, however, has been limited due to concerns of erosion, air quality, and fear of fire escapes. Building on continuing studies, researchers will look at the effectiveness of herbicides and herbicide/fire treatment effectiveness in managing these areas. Research results will provide managers with a broader array of options for achieving management goals by providing an understanding of potential tradeoffs to vegetation, fuels, mammals, reptiles, amphibians, birds, soils, diseases, insects, and economics. This project adds a National Fire and Fire Surrogate Study site in the southern Appalachian Mountains. It also adds herbicide treatment capability to the existing Piedmont site.

Project Identifier: **Waldrop, 01.SRS.C.2, Southern Research Station.**
Lead Scientist: **Thomas A. Waldrop, twaldrop@fs.fed.us, 864-656-5054.**

Assessing effects of alternative fuel management treatments on southwestern wildland-urban interface forests

Due to changes in forest density, the efforts to reduce fuels in Arizona and New Mexico forests are being challenged. Treatments that maintain forest productivity and health, sustain resource values, and are socially acceptable need to be identified and implemented. To develop such acceptable alternatives that still meet fuel reduction objectives, researchers are assessing effects of alternative fuel management treatments on forest characteristics. To further refine treatment prescriptions that minimize potential for crown fires in uneven-aged forest stands, researchers are also developing improved process-based models of fire behavior.

Project Identifier: **Edminster, 01.RMS.C.5, Rocky Mountain Research Station.**
Lead Scientist: **Carl Edminster, cedminster@fs.fed.us, 928-580-5973.**

Identifying high wildland fire risk areas and reducing future fuel loads within the Eastern United States

Current fire behavior models used for assessing wildfire risk can be improved with additional site specific and remotely sensed vegetation data and regional modeling of woody vegetation growth. Researchers are gathering this additional information to help managers identify areas of high fire risk, and to develop management options to reduce future fuel loads.

Project Identifier: **01.SRS.C.1, Southern Research Station.**
Lead Scientist: **Steve McNulty, steve_mcnulty@ncsu.edu, 919-515-9489.**

Quantifying tradeoffs of fire-fuel management options

Widespread fuel reduction treatments are needed throughout the South, particularly within the rapidly growing wildland-urban interfaces of the Coastal Plains. For decades, prescribed burning has been used in the Coastal Plain to reduce fuel loads. Now, however, this treatment is under regulatory pressure. At issue are adverse air quality and transportation safety impacts from prescribed burning smoke, as well as the potential for property losses if these burns should escape into the wildland-urban interface. While alternative fuel reduction treatments are attractive, the appropriate balance among cutting, mechanical fuel treatment, herbicide, and prescribed fire is often unclear. This study therefore examines the tradeoffs and effects of alternative fuel treatments. Results will provide managers with a broader array of options for achieving management goals.

Project Identifier: **Outcalt, 01.SRS.C.3, Southern Research Station.**
Lead Scientist: **Kenneth W. Outcalt, koutcalt@fs.fed.us, 706-559-4309.**

Achieving fuel reduction goals and restoring riparian zones to healthy conditions

Due to the absence of flooding and fire, many stream ecosystems throughout the Rocky Mountains are undergoing vegetation changes. This is reducing the potential for these sites to house a variety of threatened, endangered and state-listed species. Researchers are measuring populations of these animals and their critical habitat in burned and unburned riparian areas in Montana and New Mexico. Their results will supply guidance for restoring riparian zones to healthy conditions while simultaneously achieving fuel reduction goals.

Project Identifier: **Finch, 01.RMS.C.8, Rocky Mountain Research Station.**
Lead Scientist: **Deborah Finch, dfinch@fs.fed.us, 505-724-3671.**

The 2003 Rodeo-Chediski Fire in the Southwestern Region burned hundreds of homes. Photo: Tom Iraci, U.S. Forest Service.

Highlight Projects

Hazardous Fuel Reduction Accomplishments

One of this project's original objectives was to determine if curved material could be straightened to be successfully processed through sawmills and then used in I-beams or other engineered products.

1. Reducing fire risks in forests: Increasing the incentive to reduce hazardous fuel through harvesting and utilizing small diameter and crooked trees

Removal of forest undergrowth can help to sustain healthy forests. Currently, however, much of this type of material is felled and left on the ground or is simply chipped and burned.

To reduce fire risks in forests, researchers involved in this study are therefore working to develop marketable products from forest undergrowth and underutilized timber.

To date, three methods have been developed for using small trees that currently have little value and are seldom used.

Utilization of "No-"or "Low-Value" Forest Thinnings

Research from this project has also developed information being considered by the private sector for a low-cost processing method for the raw material (with bark) that confirms that fibrous material can be made using a chip, fiberization, and refining process.

Under this research, the potential strength properties have been evaluated and shown to be equal or greater than the minimum standards for hardboard.

Reducing Fire Risks: Scientists in this research project have illustrated that marketable products can be developed using the forest undergrowth and underutilized material that has previously been left behind after commercial tree harvest operations—adding to the fuel accumulation problem.

Success Story: No- or low-value materials are glued together and fabricated together into large structural beams at a Wyoming sawmill.

This research is also modifying an existing commercial product made by Wyoming Sawmill Inc. in Sheridan, WY. Called "LamHeader," it is an I-beam structural product that uses nominal 2 x 4 material that is then remanufactured into a more efficient structural product.

This remanufacturing process works well with small-diameter and low-value curved material. The product's performance is equal to that of existing commercial products.

The results also show that it is possible to improve properties of the I-beam through selective placement of stiffer material on the flanges.

Feasibility of Using Curved Materials for Structural Products

One of this project's original objectives was to determine if curved material could be straightened to be successfully processed through sawmills and then used in I-beams or other engineered products.

This project's research has confirmed that it *is* possible to straighten curved wood using the microwave press. After evaluating the "strength" properties of the straightened wood—as well as developing more accurate guidelines for controlling the microwave process—consistently produced thermally straightened wood can now be useable in a conventional process.

Project Identifier: **01.FPL.C.2, Forest Products Laboratory.** Lead Scientist: **John F. Hunt, jfhunt@fs.fed.us, 608-231-9433.**

2. Exploring alternatives to prescribed fire for reducing fuels inside California's high-risk urban-interface zones

California's forested urban-interface is an explosive zone of high fuel loadings, droughty conditions, and high population densities. Dwellings often are interspersed in dense thickets of shrubs with a scattered overstory of stressed trees. Using prescribed fire to reduce fuel buildup at the wildland-urban interface is often impractical because of possible litigation, air quality concerns, problems with weed invasions after fire, and fire-induced loss of ecosystem carbon and soil nutrients. Researchers are therefore examining a variety of fuel treatments as alternatives to fire to reduce fuel buildups, enhance soil properties, and improve carbon storage. The study has been established at four different sites in California. Findings will help guide managerial decisions about treating fuels in a zone of extremely high risk.

Private dwelling typical of the wildland-urban interface. Surrounding shrubs pose a fire risk. Proximity to dwellings preclude the general use of prescribed fire.

A Unique Experiment

This project's scientists reintroduced fire into plots where chipping treatments had removed fuel ladders. Chipped residues, however, are not distributed uniformly in the forest. Rather, they vary in thickness (0 to 8 inches or more), according to the spatial arrangement of understory fuels before treatment.

Might this lead to "hot spots" during burning that could damage soil or residual trees? And how might this be influenced by soil moisture at the time of burning?

The researchers approached this situation through a unique experiment in which they brought large quantities of soil and chipped residues from the field to the lab. They then placed the soil into "burn boxes"—reconstructing it in layers—and applied varying degrees of thickness of chips to the soil surfaces. In this way, they were able to simulate the range of conditions found in the field.

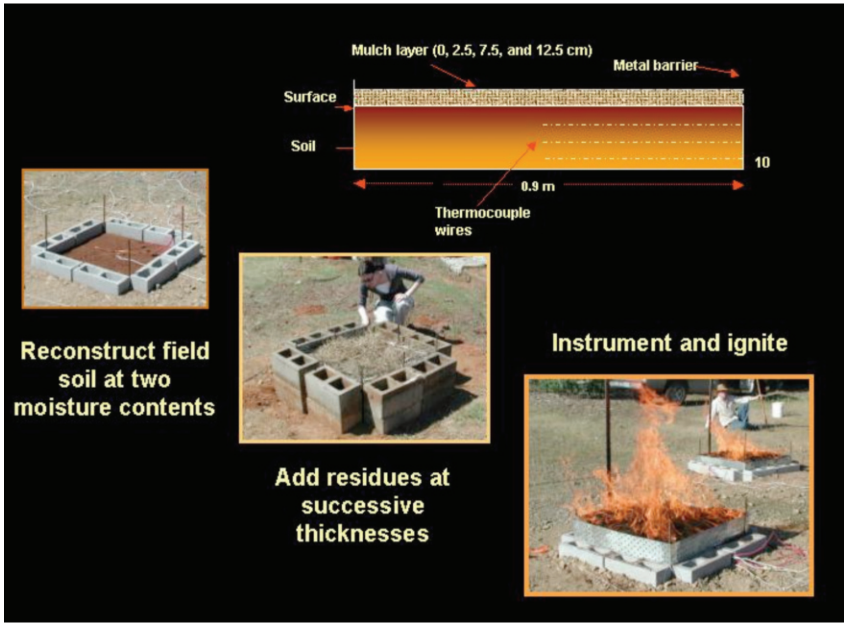
Half the soil/chip combinations were dry (simulating late summer conditions) and half were moist (simulating spring conditions). All burn boxes were instrumented with thermocouples to sense the intensity and duration of heat at varying depths below the surface.

The surfaces were then ignited (see bottom-left illustration box). Results indicate that as chip layer thickness increases, heat pulses exceeding 300 degrees C can penetrate several inches into the soil and last for several hours. The drier the soil, the greater the effect.

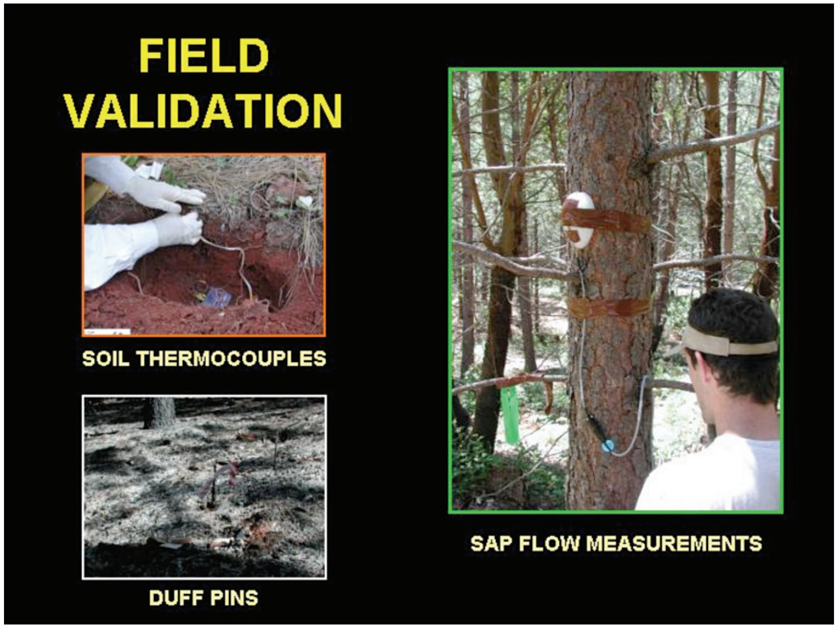
Results from this study have been accepted for publication by the *International Journal of Wildland Fire*.

Validated in the Field

The implications of this simulation experiment were then validated in the field. Thus, the first prescribed burn was applied in spring 2005 at the researcher's oldest installation (Challenge Experimental Forest). The burn was conducted according to prescriptions by Plumas National Forest employees. Duff, soil, and residual trees were instrumented to evaluate the physical and biological effects of the burn and the relationship between fuel depth and burn severity relative to soil and residual trees (see bottom-right illustration box). Results continue to be analyzed.



Layout for simulating the effect of chip depth on heat pulse.



Field instrumentation at the Challenge Prescribed Burn, spring 2005.

Project Identifier: **01.PSW.C.2, Pacific Southwest Research Station.**
Lead Scientist: **Robert F. Powers, bpowers@fs.fed.us, 530-226-2543.**

3. Developing ground-based support for mapping fuel and fire hazard for land managers

Knowledge about the condition of vegetation (fuel) is critical in assessing fire hazards and fire effects. However, we know little about the amount, distribution, and arrangement of fuels. Researchers are therefore developing techniques for monitoring and assessing fuels, mapping fuel characteristics, and validating fuel information using remote sensing. This information will enable managers to more effectively assess fire hazard conditions—as well as implement the subsequent actions to reduce these hazards.

The ongoing development of sophisticated fire behavior and effects models has highlighted this need for a comprehensive system of fuel classification that more accurately captures the structural complexity and geographic diversity of fuelbeds.

Under this special research project, a national system of fuel characteristic classification system (FCCS) is being developed. This system is designed to accommodate both managers and researchers who operate at a variety of spatial scales and have access to a variety of input data. The system quantifies live and dead fuel loadings for 16 categories of fuels across 6 vertical strata, from canopy to duff.

Under this project, scientists have monitored consumption on a variety of units to improve fuel consumption models and combustion limits for better fire use decisions.

FCCS users can accept these default settings—or modify some, or all, of them—using more detailed information about vegetation structure and fuel biomass. When the user has completed editing the fuelbed data, the FCCS calculates or infers quantitative fuel characteristics (physical, chemical, and structural properties) and probable fire parameters specific to that fuelbed.

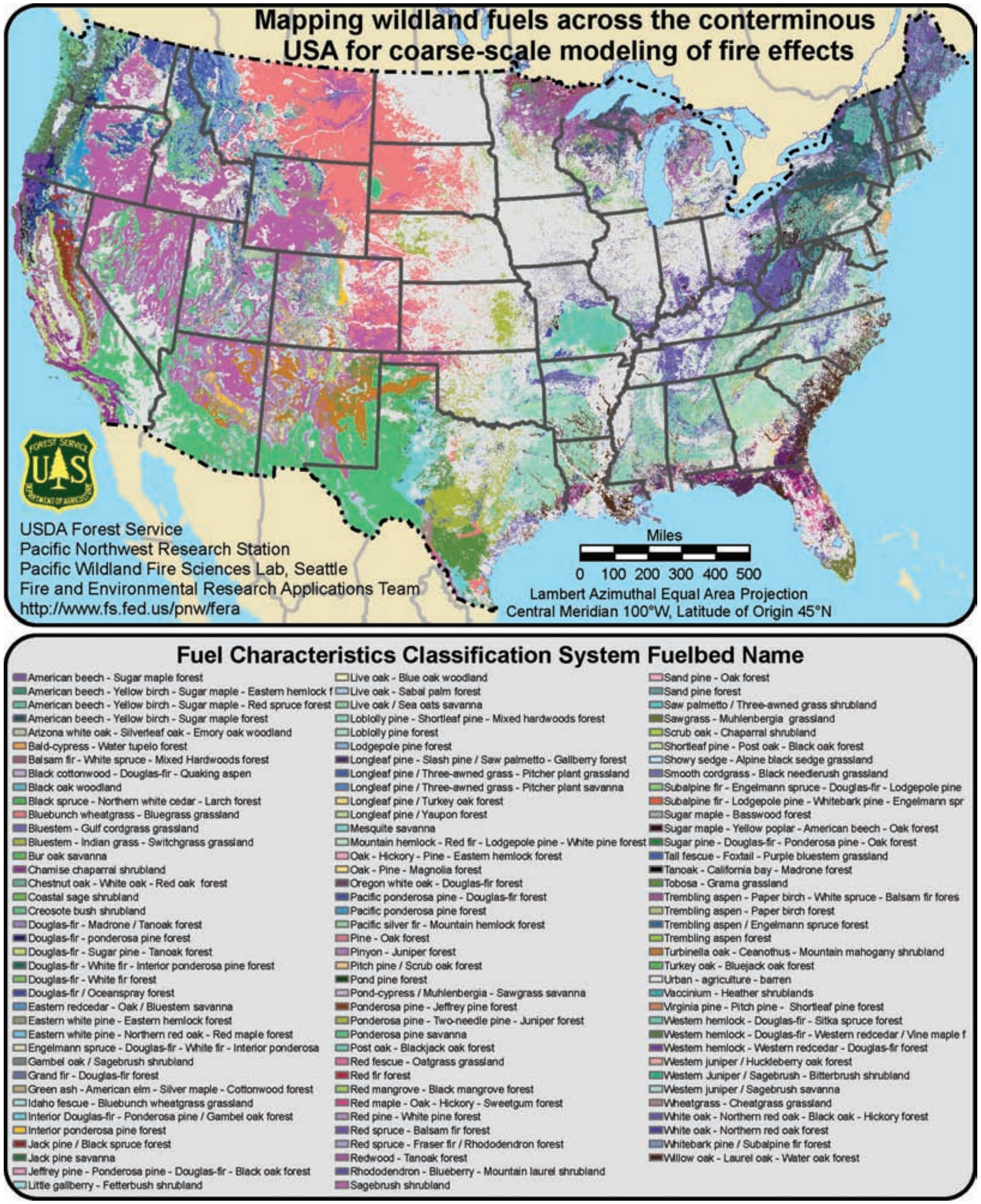
Under this project, scientists have monitored consumption on a variety of units to improve fuel consumption models and combustion limits for better fire use decisions.

Mapping Fire Hazard Potentials Also Helps a National Air Pollution Emissions Inventory

Under this project, scientists have mapped fire potentials for the United States as a fire hazard evaluation and as the basis for a national air pollution emissions inventory.

In doing so, they initiated a landscape-scale demonstration of fire potentials to serve as performance metrics and decision support for fuel treatment priorities.

To improve model predictions of fire severity and completing data collection when fuels are extremely dry, their research has also included measuring the consumption and fuel conditions on 11 very severe wildland fires and two prescribed fires in Alaska.



Fuel Characteristic Classification System (FCCS) Fuelbed Map of the Contiguous United States

Under this project scientists have developed dynamic fuel maps for the continental United States that can be updated as ecosystems change over time. An existing fuel characteristic classification system quantifies live and dead fuel loadings into means and ranges for 16 categories of fuels across 6 strata, from canopy to duff. GIS coverages of potential vegetation, current vegetation cover, land use, climatic variables, and historical fire regimes are overlaid and one or more FCCS fuelbeds are assigned to each cell on the landscape.

Several fire potentials from the fuelbed database can be calculated: fire behavior potential, crown fire potential, and available fuel potential. Local-scale data are used to validate the classifications.

The FCCS now allows land managers to visualize and quantify the distribution of fuels across the continental United States and will provide input for emissions and dispersion models under different management, land-use, and climatic-change scenarios.

A fuel-mapping module links GIS vegetation data to a fuel classification system, the Fuel Characteristic Classification System (FCCS), so that fuel loadings can be estimated across the United States. Fuel maps based on remote sensing and field data provide valuable information for modelers and managers, but are only snapshots in time.

Project Identifier:
01.PNW.C.1, Pacific Northwest Research Station.
Lead Scientist:
David V. Sandberg, dsandberg@fs.fed.us, 541-750-7265.

Accomplishments

Community Assistance

Only when communities are truly made fire safe, will our surrounding fuel treatments serve to protect them from wildfire.

To accomplish this important wildland fire protection goal, community leaders and residents must ensure that their structures and immediate surroundings are appropriately modified to reduce wildland fire risk.

As illustrated in this section, to help expedite this vital process, our National Fire Plan Research and Development is:

- ❖ Improving our understanding of community attitudes and beliefs,
- ❖ Developing new partnership approaches with communities to enhance their preparedness, and
- ❖ Also developing new partnership approaches with communities to decrease the negative social and economic impacts from wildland fires.

Building fire hazard reduction consensus through improved communication between the public and fire management agencies

Does providing additional information to people about fire management and post-fire restoration efforts make the impacts more acceptable? Does this change people's preferences for alternative techniques? Scientists are studying the effects of such information on people's perceptions and choices related to fire management techniques. This research project's goal is improving two-way communication between the public and fire management agencies in reducing fire hazard.

Project Identifier: **Kent, 01.RMS.D.1,**
Rocky Mountain Research Station.

Lead Scientist: **Brian Kent,**
bkent@fs.fed.us, 970-295-5955.

Helping managers create effective, locally acceptable fuel reduction and restoration activities

How acceptable are different fire management treatments—such as fuel reduction and restoration—to the public? And, how do different social and biophysical settings affect acceptability? To help us accurately answer these questions, researchers are examining the aesthetic and social acceptability of various forest management treatments. This information will help managers in creating effective strategies for working with the public to develop locally acceptable fuel reduction and restoration activities.

Project Identifier: **McCaffrey, 01.NCS.D.1,**
North Central Research Station.

Lead Scientist: **Sarah McCaffrey,**
smccaffrey@fs.fed.us, 847-866-9311, ext. 20.

Helping managers and wildland-urban interface residents collaborate in managing fire impacts

Fires often have a large impact on recreation and tourism, including their direct biophysical effects on the landscape and indirect effects due to fire operations, fuel treatments, area closures, and other disruptions to daily life. Researchers are therefore examining the attitudes, beliefs and behaviors of local residents as well as area visitors affected by fire events. Results from this research will help managers and people in wildland-urban interface communities to work together in better managing these impacts.

Project Identifier: **Chavez, 01.PSW.D.1,**
Pacific Southwest Research Station.

Lead Scientist: **Deborah Chavez,**
dchavez@fs.fed.us, 951-680-1558.

Identifying educational program effectiveness for mitigating wildland fire hazards

The danger to homes located adjacent to wildlands can be greatly reduced with public education and a good mix of programs, including: land use zoning, fire-safe building codes, and vegetation management controls. Researchers are examining the wide range of regulatory, incentive-based, and educational programs currently used to reduce fuel loading in fire-prone communities and identifying these programs' effectiveness in mitigating fire hazards.

Project Identifier: **Haines, 01.SRS.D.2, Southern Research Station.**
Lead Scientist: **Terry Haines, thaines01@fs.fed.us, 985-867-9164.**

Landscapes that people create and manage around their homes influence the susceptibility of their residences to wildfire. Photo: Tom Iraci, U.S. Forest Service.

Developing alternative residential landscape designs to meet owners' landscape needs and increase fire safety

The landscapes that people create and manage around their homes influence the susceptibility of their residences to wildfire. Little research on "firewise" landscapes has taken into consideration what vegetation characteristics homeowners consider most important—for instance, beauty, shade, privacy, and wildlife habitat. Researchers are developing a set of alternative landscape designs that will enable homeowners to meet their personal landscape needs—and simultaneously increase fire safety.

Project Identifier: **McPherson, 01.PSW.D.2, Pacific Southwest Research Station.**
Lead Scientist: **Greg McPherson, egmcpherson@ucdavis.edu, 530-752-5897.**

What characteristic enabled this house to survive the flames? Photo: Tom Iraci, U.S. Forest Service.

Preventing residential fire disasters at the wildland-urban interface

News reports on fires often dramatically depict one house virtually untouched by fire standing among its completely ruined neighbors. What characteristics enable this one house to survive the flames? Under this important project, researchers are looking into what specific home design factors contribute to home ignitions. This information is critical to the development of "Firewise" for homes and communities. This project is nationally applicable, with research efforts and investigations conducted principally in the western United States, including Alaska and Alberta and Northwest Territories, Canada. Among other research products, a three-method approach has been applied to the problem of homes igniting during wildfires.

Project Identifier: **01.RMS.D.2, Rocky Mountain Research Station.**
Lead Scientist: **Jack D. Cohen; jcohen@fs.fed.us; 406-329-4821.**

Mapping the wildland-urban interface across the United States and projecting its growth to 2030

The wildland-urban interface areas are where firefighting is most challenging. Communities, homes, and property are at most risk here. And, the likelihood of danger to human life is greatest in these interface areas. However, we know very little about the wildland-urban interface location, extent, and change over time. Scientists are therefore developing valid methods for estimating housing density at a fine scale over a long time period (1940-2030) across the United States. Through this comprehensive effort, it will be possible to clearly delineate wildland-urban interface areas and track their growth and change over time. This information will allow policy makers and fire professionals to better coordinate and prioritize hazard mitigation projects, and will also assist states and communities in their efforts to reduce wildland fire vulnerability of homes and communities.

Project Identifier: **Stewart, 02.NCS.D.1, North Central Research Station.**
Lead Scientist: **Susan I. Stewart, sistewart@fs.fed.us, 847-866-9311, ext. 13.**

Increasing the effectiveness of fire management programs in communities at risk from wildfire

The vulnerability of wildland-urban interface communities to fire is a function of a variety of factors, including the community's organizational culture and its ability to coordinate with nearby communities. Under this project, researchers will gather information from communities that have been successful in disaster preparedness. In doing so, they will identify what factors are critical to success and develop models of community cooperation and partnerships. This information will help to increase the effectiveness of fire management programs in communities at risk from wildfire.

Project Identifier: **Jakes, 01.NCS.D.2, North Central Research Station.**
Lead Scientist: **Pamela J. Jakes, pjakes@fs.fed.us, 651-649-5163.**

Sign says it all. Photo: Tom Iraci, U.S. Forest Service.

Assisting land managers in designing and implementing socially acceptable fire and fuel management policies and programs

Although fire is increasingly recommended as a vegetation management tool on both public and private lands, controversy often inhibits its use. A lack of communication and understanding between land managers and the public contributes to these difficulties. Researchers are therefore gathering information on public knowledge, beliefs, and attitudes related to fire use, fuel management, and the role of fire in Southwestern (New Mexico and Arizona) ecosystems. They are also examining the factors contributing to successful public involvement with fire and fuel management planning approaches. Results of this research will assist land managers in designing and implementing successful, socially acceptable, fire and fuels management policies and programs.

Project Identifier: **Raish, 02.RMS.D.1, Rocky Mountain Research Station.**

Lead Scientist: **Carol Raish, craish@fs.fed.us, 505-724-3666.**

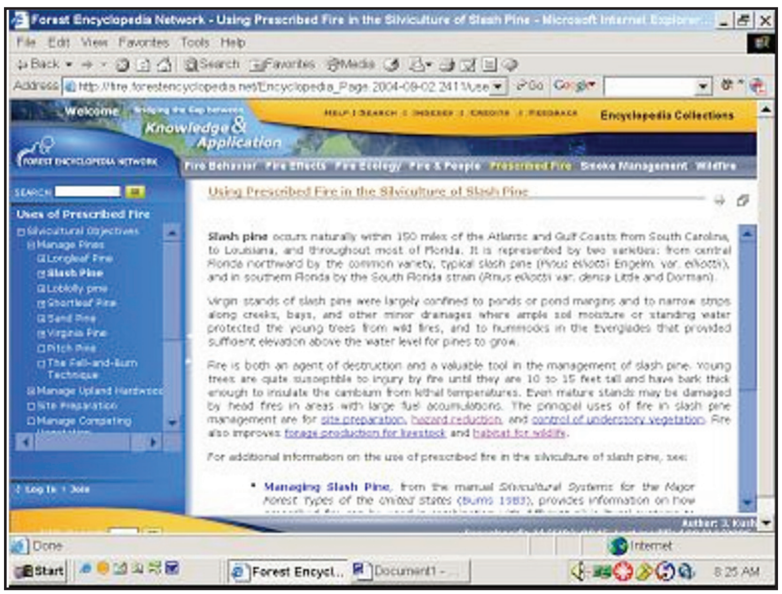
Highlight Projects

Community Assistance Accomplishments

1. Developing a convenient internet-based encyclopedia of southern fire science and management knowledge

Managers use prescribed fire for various objectives. The widespread use of prescribed fire has increased the complexity for management in the south. Much research information is available to help land managers make decisions about how and when to use fire. But this information is scattered in written reports that range from user bulletins to refereed journal articles. Managers can become overwhelmed when searching these vast written resources.

The objective of this project is to gather the fragmented information contained in a mass of publications into a synthesized, centrally located database that is easily accessible and searchable by all users.



Encyclopedia of Southern Fire Science Web page.

A comprehensive outline was developed for all aspects of southern fire science. This was used as the basis for building an Internet-based hypertext encyclopedia. Authors were recruited to develop content—synthesized information—presented in a hierarchical form from general explanation to detailed science, with cross links to related topics throughout the system.

Content was peer reviewed over the Internet by appropriate scientists from throughout the southern fire science cadre. Using review comments, authors then revised the synthesis articles and edited them for style. Finalized articles were then published on the Web site. Using content management system software, a user-friendly knowledge-based encyclopedia of southern fire science was thus created that provides ready access to the correct information.

Fully Searchable Knowledge Base

The *Encyclopedia of Southern Fire Science* is available free on the Web at http://www.fire.forestencyclopedia.net. It is a fully searchable knowledge base containing seven major sections: fuels, weather, and fire behavior; fire effects on air, water, soil, vegetation, and fauna; fire ecology; fire and people; prescribed fire; smoke management; and wildland fire. More than 1000 pages of content in the Fire Encyclopedia synthesize southern fire science and provide an extensive reference list. Links to other Web sites contain additional information about specific topics in southern fire science.

To assist in making informed decisions by providing a better understanding of the social, economic, and ecosystem implications of *all* aspects of southern fire, the synthesized information contained in the *Encyclopedia of Southern Fire Science* is now readily available to community leaders, land managers, policy makers, and private landowners.

An Internet-based fire science encyclopedia system – from fire and people to smoke management

The *Encyclopedia of Southern Fire Science* is organizing and synthesizing the southern United States' large body of fire science and translating this information into an Internet-based encyclopedia system.

RWU-4104 is cooperating with a variety of research institutions and land management agencies across the South to compile literature and write original syntheses of a broad range of topics, including:

- Fire and people;
- Fuels and fire behavior;
- Fire effects;
- Ecology of fire-influenced communities in the South;
- Uses and types of prescribed fire;
- Fire weather and smoke management; and
- Wildfire occurrence, impacts, and mitigation.

These syntheses will be available to the public in a fully-linked and searchable encyclopedia hypertext system via the Internet, making access to this information universal, convenient, and free.

Project Identifier: **02.SRS.D.1, Southern Research Station.**

Lead Scientist: **Kenneth W. Outcalt, koutcalt@fs.fed.us, 706-559-4309.**

2. Economic impact research to help future Federal assistance structuring in the aftermath of catastrophic fire

Catastrophic wildfires incur a large economic toll on communities, including property losses, decreased tourism, and even changes in the long-term structure of the local economy. Building on experiences gained in evaluating the economic impacts of fires in Florida, researchers are evaluating the economic impacts of fires across the western United States. Insights gained from this research will help provide guidance for structuring Federal assistance in the aftermath of catastrophic fires.

Background

In 2005, the Forest Service was asked to identify alternative approaches that could be considered for estimating annual suppression costs and the funding of wildfire suppression. The Forest Service and Department of the Interior agencies agreed to work together to improve their methods for estimating annual wildfire suppression costs. It was determined that developing improved methods would more effectively account for annual changes in costs—as well as the uncertainties associated with wildfires. Thus, funding needs for wildfire suppression could be predicted with greater accuracy.

However, it was eventually determined that the current approach—based on a 10-year moving average—did not provide sufficient information to determine these improved methods.

Accomplishments

A subsequent two-year collaboration joined the Southern Research Station, Rocky Mountain Research Station, and Scripps Institution of Oceanography. Researchers from these three institutions worked together to provide the Forest Service with more accurate indicators of upcoming fire season severity—for both "area burned" and "emergency suppression" expenditures.

The agency asked these collaborating scientists to develop statistical models that would:

1. Possibly replace the current budget appropriation request tool that the agency currently uses (the 10-year moving average cost—[see below]), and
2. Indicate the severity of the upcoming fire season through simulation modeling.

These approaches have been useful for reducing budget surprises. They have also served as indicators of the size and likelihood of the need for supplemental budget appropriations.

Investigating Statistical Alternatives to the 10-year Moving Average

Alternatives were evaluated for three different time "horizons":

- ❖ The Fall Current Year Model—which makes a forecast at the beginning of the fiscal year for the current fiscal year;
- ❖ The Late Statistical Budget Prediction Model—made two years out; and
- ❖ The Early Statistical Budget Prediction Model—made three years out.

These approaches have been useful for reducing budget surprises. They have also served as indicators of the size and likelihood of the need for supplemental budget appropriations.

Researchers discovered that these alternatives:

- ❖ Improve the statistical accuracy of forecasts of emergency suppression costs, and
- ❖ Reduce the error rate by nearly 50 percent when compared to the 10-year moving average.

Of the alternatives investigated, the best statistical forecast of fiscal year 2005 suppression costs made in October 2004 was $395 million—with the 95 percent confidence interval ranging from $87 million to $737 million.

The best "two-year out" model forecast (for fiscal year 2006 using October 2004 data) was $875 million—with the 95 percent confidence interval ranging from $517 million to $1,993 million.

And, the best "three-year out" model (for fiscal year 2007 using October 2004 data) was $891 million—with the 95 percent confidence interval ranging from $476 million to $2,093 million.

Project Identifier: **01.SRS.D.1, Southern Research Station.**

Lead Scientist: **Jeffrey P. Prestemon, jprestemon@fs.fed.us, 919-549-4033.**

Table 2—National Fire Plan Research and Development Program Projects and Team Lead Scientists

Project ID number	Project title	Team lead scientists	E-mail address
A. Firefighting			
01.NCS.A.1	National and Regional Fire-Weather Dynamics: Improved Methods for High Resolution Forecasting of Fire-Weather Indices and Smoke Transport	Warren E. Heilman	wheilman@fs.fed.us
01.NCS.A.1	National and Regional Fire-Weather Dynamics: Improved Methods for High Resolution Forecasting of Fire-Weather Indices and Smoke Transport	Warren E. Heilman	wheilman@fs.fed.us
01.NCS.A.2	Assessing Vulnerability of Populations to Wildfire in the North Central Region	Robert G. Haight	rhaight@fs.fed.us
01.NCS.A.3	FIA Pilot Test of a Fuel Condition Monitoring System	Dennis May	dmay@fs.fed.us
01.PNW.A.1	A Modeling Framework for Real-time Predictions of Cumulative Smoke Impacts (“BlueSky”)	Brian Potter	bpotter@fs.fed.us
01.PNW.A.2	Estimating Haze from Prescribed and Wildland Fires	Don McKenzie	donaldmckenzie@fs.fed.us
01.PNW.A.3	Seasonal Prediction of National Fire Risks and Impacts	Ronald P. Neilson	rneilson@fs.fed.us
01.PNW.A.4	Fuel Moisture Mapping and Combustion Limits	David V. Sandberg	dsandberg@fs.fed.us
01.PSW.A.1	Risks to Fish and Wildlife from Wildfire and Landscape Treatments	Danny C. Lee	dclee@fs.fed.us
01.PSW.A.2*	An Initial Attack Model for Fire Management Planning	Marc Wiitala	mrwiitala@fs.fed.us
01.PSW.A.3	Fire Behavior in Live Fuels	David R. Weise	dweise@fs.fed.us.
01.PSW.A.4	Real-time Remote Sensing of Fire Properties	Philip J. Riggan	priggan@fs.fed.us
01.PSW.A.5	Weather Models for Area Coordination Centers	Francis Fujioka	ffujioka@fs.fed.us
01.RMS.A.1	Improving Decisions for Fuel Treatment Options	J. Greg Jones	jgjones@fs.fed.us
01.RMS.A.2	Real-time Fire Monitoring Nationwide	Wei Min Hao	whao@fs.fed.us
01.RMS.A.3	New Technology for Monitoring Smoke Characteristics	Wei Min Hao	whao@fs.fed.us
01.RMS.A.4	Remote Sensing, GIS and Landscape Assessment Tools for Fire Management	Robert E. Keane	rkeane@fs.fed.us
01.RMS.A.5	Fire Management Strategies for Wilderness and Other Protected Areas	Carol Miller	cmiller04@fs.fed.us
01.SRS.A.1	Prediction of Fire Weather and Smoke Impacts in the Southeast	Gary L. Achtemeier	gachtemeier@fs.fed.us
01.SRS.A.2	Trade-offs of Alternative Vegetation Management Strategies	Jeffrey P. Prestemon	jprestemon@fs.fed.us
01.SRS.A.3	Establishing a Wildland-Urban Interface Research and Technology Transfer Unit for the South	Edward Macie	emacie@fs.fed.us
01.SRS.A.4	Long-range Forecasting of Fire Season Severity	Scott Goodrick	sgoodrick@fs.fed.us
01.SRS.A.5	Southern Regional Models for Predicting Smoke Movement	Gary L. Achtemeier	gachtemeier@fs.fed.us
02.NES.A.1	Regional Climate and Fire Danger Modeling for the New Jersey the Pine Barrens	John Hom	jhom@fs.fed.us
02.PSW.A.1	Improving Monitoring and Modeling of Smoke Contributions to Regional Haze	Andrzej Bytnerowicz	abytnerowicz@fs.fed.us
02.RMS.A.1	Enhanced Prediction of Fire Weather and Smoke Impacts in the Rocky Mountains and the Southwest	Karl Zeller	kzeller@fs.fed.us
02.RMS.A.2	A Nationwide System to Generate a Daily Emissions Inventory of Pollutants from Fires	Wei Min Hao	whao@fs.fed.us

Table 2—National Fire Plan Research and Development Program Projects and Team Lead Scientists (continued)

Project ID number	Project title	Team lead scientists	E-mail address
B. Rehabilitation and Restoration			
01.PNW.B.1	Predicting Spread of Invasive Species After Fuel Reduction Treatments and Postfire Disturbance	Edward J. DePuit	ejdepuit@fs.fed.us
01.PSW.B.1	Effectiveness of Postfire Emergency Rehabilitation Treatments in the West	Jan L. Beyers	jbeyers@fs.fed.us
01.RMS.B.1	Hydrologic and Geomorphic Consequences of Wildfire and Fuels Management Options in Southwest Forest and Woodland Ecosystems	Daniel G. Neary	dneary@fs.fed.us
01.RMS.B.2	Native Plant Materials for Restoration of Sagebrush Steppe and Pinyon-Juniper Communities	E. Durant MacArthur	dmcarthur@fs.fed.us
01.RMS.B.3 *	Dynamics of Weed Invasions and Fire in the Northern Rockies	George Markin	gmarkin@fs.fed.us
01.RMS.B.4	Effects of Wildfire and Fire Management Options on Invasive and Exotic Species and Pathogens	Karen Clancy	kclancy@fs.fed.us
01.RMS.B.5	Factors Affecting Great Basin Watersheds' Susceptibility to Invasive Plants	Jeanne C. Chambers	jchambers@fs.fed.us
01.RMS.B.6*	Patterns of White Pine Regeneration after Fire	Anna Schoettle	aschoettle@fs.fed.us
01.RMS.B.7	The Role of Grassland Fire in Managing Exotic and Woody Plants	Deborah M. Finch	dfinch@fs.fed.us
02.PNW.B.1*	Response of Native and Invasive Exotic Plants to Fire and Fuel Reduction in the Interior Pacific Northwest	Catherine Parks	cparks01@fs.fed.us
02.RMS.B.1	Characterizing Risks of Wildfire and Fuels Management in Aquatic Systems	Bruce Rieman	brieman@fs.fed.us
02.SRS.B.1	Modeling the Effects of Wildfire on Sediment and Nutrient Loads in the Southeastern U.S.	Jim Vose	jvose@fs.fed.us
C. Hazardous Fuel Reduction			
01.FPL.C.1	Hazardous Fuel Reduction through Harvesting Underutilized Trees and Forest Undergrowth and Producing Three-Dimensional Structural Products	John F. Hunt	jfhunt@fs.fed.us
01.FPL.C.2	Utilization of Small Diameter Crooked Timber for Use in Laminated Structural Boards Through Development of New Sawing, Laminating, and Drying Processes	John F. Hunt	jfhunt@fs.fed.us
01.NCS.C.1	Optimizing Fuel Reductions in Time and Space	Brian Palik	bpalik@fs.fed.us
01.NCS.C.2	Managing Risk of Fire on Communities in the Wildland-Urban Interface	Eric Gustafson	egustafson@fs.fed.us
01.NES.C.1	Fuels and Fire Behavior in the Central Hardwoods	Matthew Dickinson	mbdickinson@fs.fed.us
01.PNW.C.1	Ground-based Support for Mapping Fuel and Fire Hazard	David V. Sandberg	dsandberg@fs.fed.us
01.PNW.C.2	Fuel Reduction and Forest Restoration Strategies that Sustain Key Habitats and Species in the Interior Northwest	John F. Lehmkuhl	jlemkuhl@fs.fed.us
01.PSW.C.1	Effects of Fuel Reductions on Stream Ecosystems	Carolyn T. Hunsaker	chunsaker@fs.fed.us
01.PSW.C.2	Alternatives to Fire for Fuel Reduction in California Shrublands within Coniferous Forest	Robert F. Powers	rpowers@c-zone.net
01.PSW.C.3*	The Effect of Prescribed Fire on Hydrologic and Soil Processes that Affect Erosion in Semi-Arid Systems	Ken Hubbert	khubbert@fs.fed.us
01.PSW.C.4	Effects of Wildfire and Fuel Treatments on California Spotted Owl	John J. Keane	jkeane@fs.fed.us
01.RMS.C.1	Impacts of Exotic Weeds on Fuel Loading and Fire Regimes	Nancy L. Shaw	nshaw@.fs.fed.us
01.RMS.C.2	Impact of Fuel Management Treatments on Fire Behavior and Forest Vegetation	Dennis E. Ferguson	deferguson@fs.fed.us
01.RMS.C.3	Impact of Fuel Management Treatments on Forest Soil Erosion and Production	William J. Elliot	welliot@fs.fed.us
01.RMS.C.4	Management Alternatives for Fire Dependent Ecosystems in Colorado and the Black Hills	Linda A. Joyce	ljoyce@fs.fed.us

Table 2—National Fire Plan Research and Development Program Projects and Team Lead Scientists (continued)

Project ID number	Project title	Team lead scientists	E-mail address
01.RMS.C.5	Improved Guidelines for Fuel Management in Southwestern Ponderosa Pine and Pinyon Juniper Forests in Wildland-Urban Interface Areas	Carlton B. Edminster	cedminster@fs.fed.us
01.RMS.C.6	Restoration Techniques in Lodgepole Pine Forests	Ward McCaughey	wmccaughey@fs.fed.us
01.RMS.C.7*	Use of Remote Sensing to Examine Disturbance Effects	John E. Lundquist	jlundquist@fs.fed.us
01.RMS.C.8	Riparian Ecosystem Dynamics in Relation to Fire in the Rocky Mountains	Deborah M. Finch	dfinch@fs.fed.us
01.SRS.C.1	Wildfire Risk in the Eastern United States	Steve McNulty	steve_mcnulty@ncsu.edu
01.SRS.C.2	Quantifying the Ecological and Economic Tradeoffs of Fire and Fire Surrogate Options for Piedmont and Southern Appalachian Mountains	Thomas A. Waldrop	twaldrop@fs.fed.us
01.SRS.C.3	Quantifying the Tradeoffs of Fire and Fuels Management Options - Longleaf and Slash Pine Ecosystems of the Atlantic and Gulf Coastal Plain Provinces	Kenneth W. Outcalt	koutcalt@fs.fed.us
01.SRS.C.4	A System for Mechanized Fuel Reduction at the Wildland-Urban Interface	John Stanturf	jstanturf@fs.fed.us
01.SRS.C.5	Fire and Herbicide Combinations to Reduce Fire Intensity	Joseph O'Brien	jjobrien@fs.fed.us
02.FPL.C.1	Developing Tools to Assess the Economic Feasibility of Processing Wood Removed in Hazardous Fuels Reduction	Ken Skog	kskog@fs.fed.us
02.PNW.C.1	Processing Options for Hazardous Fuel Reduction	Jamie Barbour	jbarbour01@fs.fed.us
02.PSW.C.1	Assessing Alternative Fire and Fuels Management Approaches on Fish and Wildlife: Plan for the Quincy Library Group Study Area	Peter Stine	pstine@fs.fed.us
02.RMS.C.1	Environmental and Economic Impacts of Biomass Reduction	William J. Elliot	welliot@fs.fed.us
02.RMS.C.2	Effects of Wildland Fire and Fuel Treatments on Terrestrial Vertebrates in Intermountain Forests	William Block	wblock@fs.fed.us
D. Community Assistance			
01.NCS.D.1	Modeling People's Responses to Landscape Treatments	Sarah McCaffrey	smaccaffrey@fs.fed.us
01.NCS.D.2	Community Partnerships	Pamela J. Jakes	pjakes@fs.fed.us
01.PSW.D.1	Recreation and Fire in the Wildland-Urban Interface	Deborah Chavez	dchavez@fs.fed.us
01.PSW.D.2	Firewise Residential Landscapes	Greg McPherson	egmcpherson@ucdavis.edu
01.RMS.D.1	Building Consensus on Fire Management	Brian Kent	bkent@fs.fed.us
01.RMS.D.2	Preventing Residential Fire Disasters at the Wildland-urban Interface	Jack D. Cohen	jcohen@fs.fed.us
01.SRS.D.1	Impact of Wildfires on Local Economies	Jeffrey P. Prestemon	jprestemon@fs.fed.us
01.SRS.D.2	Fire Protection in Residential Expansion Areas	Terry Haines	thaines01@fs.fed.us
02.NCS.D.1	Mapping the Wildland Urban Interface and Projecting its Growth to 2030	Susan Stewart I.	sistewart@fs.fed.us
02.RMS.D.1	Community Knowledge, Beliefs, Attitudes and Practices Concerning Fire and Fuels Management in Southwestern Ecosystems	Carol Raish	craish@fs.fed.us
02.SRS.D.1	An Internet-Based Encyclopedia of Southern Fire Science and Management Knowledge	Kenneth W. Outcalt	koutcalt@fs.fed.us

* Projects unfunded in fiscal year 2004

Table 3A— 2004 National Fire Plan Research and Development Program Summary Accomplishments

Accomplishment	Firefighting	Rehabilitation and restoration	Hazardous fuel reduction	Community assistance
Studies initiated	64	18	72	20
$$ Value of agreements (1000s)	$2,896.00	$520.50	$2,226.50	$1,002.00
Permanent scientists/professionals hired	4.08	0.3	4.5	75
Term scientists/professionals hired	5	2	8.5	0
Permanent technicians hired	1	0	3	0
Refereed publications	50	23	51	16
Non-refereed publications	69	68	90	35
Presentations at scientific conferences	219	129	176	91
User bulletins, leaflets produced	51	3	29	34
Decision-support tools, models developed	77	1	22	6
Demonstrations, tours hosted	87	31	92	10
Regions, National Forests, Districts	88	36	142	48
States, State Foresters	40	12	31	18
Tribal Governments	6	9	6	5
County/local governments	9	11	25	25
Other	55	24	59	51
Short courses, workshops, training offered	34	16	68	19
Communities assisted	1	6	16	24
Fire Management units assisted	27	5	21	29

Table 3B— 2005 National Fire Plan Research and Development Program Summary Accomplishments

Accomplishment	Firefighting	Rehabilitation and restoration	Hazardous fuel reduction	Community assistance
Studies initiated	67	13	50	25
$$ Value of agreements (1000s)	$2,252.00	$567.80	$1,894.60	$961.00
Permanent scientists/professionals hired	2.2	0	4	0
Term scientists/professionals hired	2.7	1	8.5	0
Permanent technicians hired	1	0	18	0
Refereed publications	53	24	69	23
Non-refereed publications	61	84	77	24
Presentations at scientific conferences	216	122	184	51
User bulletins, leaflets produced	58	4	37	30
Decision-support tools, models developed	84	1	13	7
Demonstrations, tours hosted	95	32	68	5
Regions, National Forests, Districts	93	26	121	33
States, State Foresters	42	8	21	21
Tribal Governments	2	2	3	1
County/local governments	7	6	31	19
Other	61	12	52	28
Short courses, workshops, training offered	48	22	91	15
Communities assisted	1	4	20	26
Fire Management units assisted	42	7	23	37

Table 4—2004 and 2005 Research Partners and Cooperators for Forest Service National Fire Plan Research

Partner/Cooperator	Firefighting	Rehabilitation and restoration	Hazardous fuel reduction	Community assistance
Adaptive Management Services				X
Air Sciences Inc	X		X	
AKB Reforestation			X	
Allied En vironmental and Forestry Consultants			X	
Anadarko Industries			X	
Association of Official Seed Certifying Agencies			X	
ATMET Inc	X			
Auburn University	X		X	
Axiom IT Solutions	X			
Bitterroot Ecosystem Management Project			X	
Black Hills State University			X	
Boise State University		X	X	
Brigham Young University	X			
Bureau of Land Management				X
California State University			X	
Carmelia Austin				
Carol Jones				
Catamount Institute			X	
Charlie Jackson		X		
Clemson University			X	
Colorado State University	X		X	
Columbia University				
Cortner & Associatges				X
Darin Law				
Decision Science Research Institute Inc				X
Desert Research Institute	X			
Douglas Ranger District				
Farber Specialty Vehicles	X			
Geertson Seed			X	
George Mason University	X			

Table 4—2004 and 2005 Research Partners and Cooperators for Forest Service National Fire Plan Research (continued)

Partner/Cooperator	Firefighting	Rehabilitation and restoration	Hazardous fuel reduction	Community assistance
Gordon Johnson				
Hall Environmental Analysis Laboratory				
Helena National Forest			X	
Hira Walker				
Hoefler Consulting	X		X	
Hubbert and Associates				
Integrated Resource Solutions				X
ITT Technical Institute	X			
Jemez Ranger District			X	
Kathy Brodhead				
Kiowa National Grassland				
Lang, Railsback and Associates				
Lans Thornton				
Larry Allen				
Los Alamos National Laboratory	X		X	
Louisana State University			X	X
Manual Gonzales		X		
METI			X	
Michigan State University	X		X	X
Missoula Tech. & Dev. Center			X	
Montana Conservation Corps			X	
Montana State University		X	X	
National Oceanic and Atmospheric Administration	X			
NC - 4401 Eastern Area Modeling Consortium	X			
New Mexico State University		X	X	
NOAA Air Resources Laboratory	X			
North Carolina State University	X		X	
Northern Arizona University		X	X	
Ohio University			X	
Ohlson Inc			X	

Table 4—2004 and 2005 Research Partners and Cooperators for Forest Service National Fire Plan Research (continued)

Partner/Cooperator	Firefighting	Rehabilitation and restoration	Hazardous fuel reduction	Community assistance
Oregon State University	X	X		X
Pacific Northwest Research Station			X	
Phil Dawson	X			
Plumas National Forest			X	
Qualcomm Inc	X			
Robert Lamar - Pilot	X			
Robinson Research				X
Rocky Mountain Tree-Ring Research		X		
Saint Louis University		X		
Scripps Institution of Oceanography	X			
Seedyco Inc			X	
SI International		X	X	
Sonoma Technology				
Space Instruments Inc.	X			
Sr. Dmitry Sukhov			X	
State of Utah				X
State University of New York	X			
Steven Bodio		X		
Systems for Environmental Management	X			
Texas A & M University			X	X
The Nature Conservancy			X	
Titan Averstar	X			
Total Forestry			X	
University of Arizona		X	X	
University of California	X		X	
University of California				
University of Colorado		X		X
University of Florida	X			
University of Georgia	X			
University of Hawaii	X			

Table 4—2004 and 2005 Research Partners and Cooperators for Forest Service National Fire Plan Research (continued)

Partner/Cooperator	Firefighting	Rehabilitation and restoration	Hazardous fuel reduction	Community assistance
University of Hawaii	X			
University of Houston	X			
University of Idaho	X	X	X	
University of Maryland			X	
University of Massachusetts				X
University of Minnesota				X
University of Missouri	X		X	
University of Montana	X		X	
University of Nevada		X		
University of Nevada Reno				X
University of New Mexico		X		
University of North Carolina			X	
University of Oklahoma			X	
University of Sao Paulo, Brazil	X			
University of Tennessee			X	
University of Utah	X			
University of Washington	X		X	
University of Wisconsin	X		X	X
University of Wyoming		X	X	
US Army Research Laboratory	X			
USDA FS Forest Inventory Science			X	
US Geological Survey			X	X
Virginia Polytechnic Institute and State University	X			X
Washington State University	X		X	X
Weather Ventures Ltd.	X			
West Virginia University				X
Western New Mexico University		X		
Western Washington University				X

ROCKY MOUNTAIN
Research Station

The Rocky Mountain Research Station develops scientific information and technology to improve management, protection, and use of the forests and rangelands. Research is designed to meet the needs of National Forest managers, Federal and State agencies, public and private organizations, academic institutions, industry, and individuals.

Studies accelerate solutions to problems involving ecosystems, range, forests, water, recreation, fire, resource inventory, land reclamation, community sustainability, forest engineering technology, multiple use economics, wildlife and fish habitat, and forest insects and diseases. Studies are conducted cooperatively, and applications may be found worldwide.

Research Locations

Flagstaff, Arizona
Fort Collins, Colorado*
Boise, Idaho
Moscow, Idaho
Bozeman, Montana
Missoula, Montana
Reno, Nevada
Albuquerque, New Mexico
Rapid City, South Dakota
Logan, Utah
Ogden, Utah
Provo, Utah

*Station Headquarters, Natural Resources Research Center,
2150 Centre Avenue, Building A, Fort Collins, CO 80526