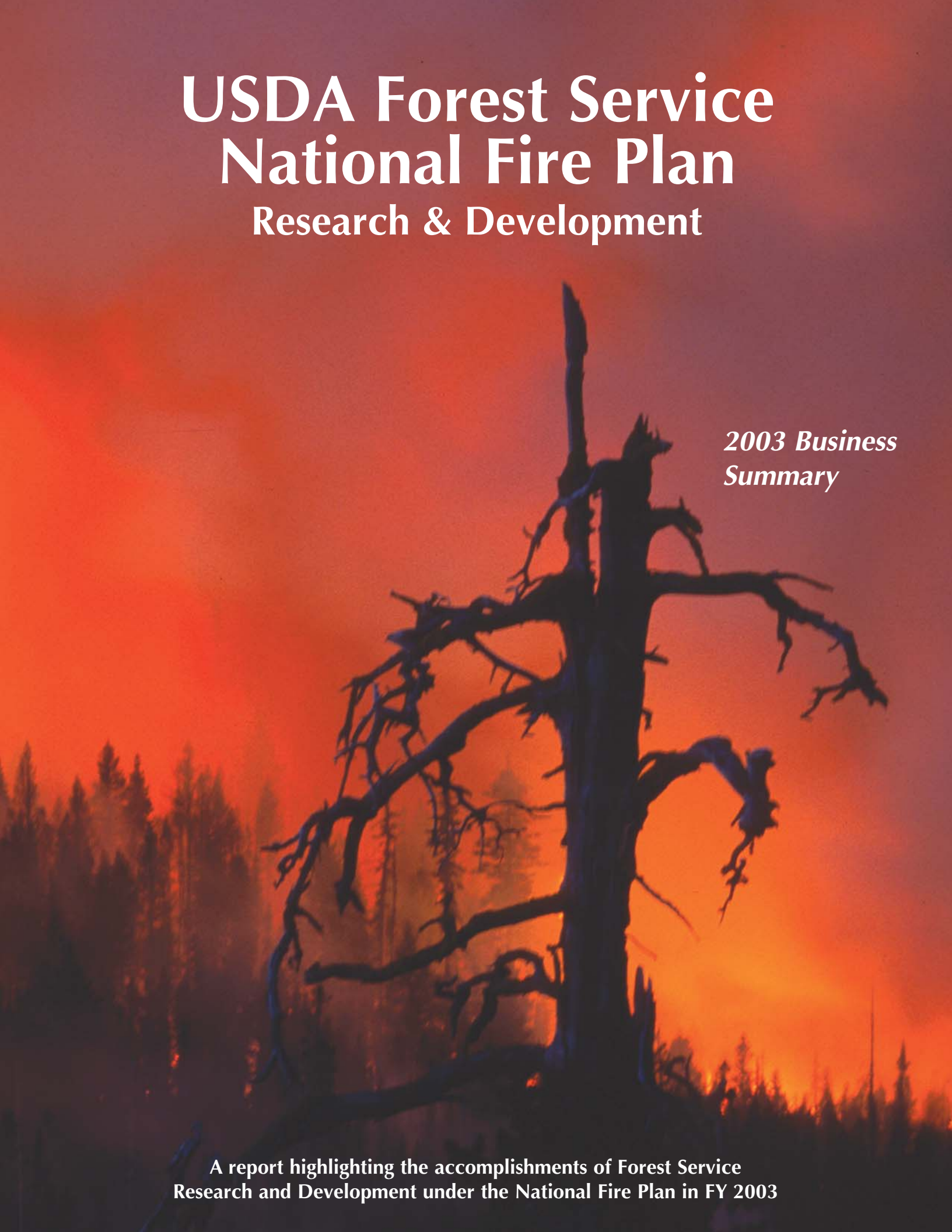
USDA Forest Service National Fire Plan

Research & Development



2003 Business Summary

A report highlighting the accomplishments of Forest Service Research and Development under the National Fire Plan in FY 2003

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The National Fire Plan
USDA Forest Service

Managing the Impacts of Wildfires on Communities and the Environment

Acknowledgments

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Executive Summary

Executive Summary

As the United States continues to have unusually severe fire seasons, science-based knowledge and tools developed by National Fire Plan (NFP) research are rapidly being used by managers. These tools are helping managers better predict potential fire hazard, fire growth, and smoke impacts; evaluate fire behavior and fire severity more accurately and rapidly; improve their planning for postfire 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. New information and tools are helping communities and homeowners to better understand what they can do to reduce wildland fire risk to their communities, and are helping managers to understand how to best work with communities in collaborative planning efforts. New information is helping wilderness managers to better predict where fires can be allowed to burn naturally without causing severe ecosystem damage or hazard to communities. Syntheses of existing knowledge are building our understanding of the impacts of fire and fuel treatments on aquatic systems and fish populations.

In 2003, in the third year of the NFP, Forest Service Research and Development (R&D) received $27 million in appropriated and carryover funding from the NFP. The R&D projects are being carried out in all 50 States. Seventy-eight 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 NFP built on newly developed tools and databases to provide critical assistance to Federal, State, and local governments as they responded to the numerous fires in the interior West in summer 2003.

Guided by the strategic goals outlined in the NFP and the 10-year Comprehensive Strategy and Implementation Plan (which expanded the NFP focus into a broad, collaborative effort among multiple Federal agencies and their partners), fire research continued to actively address crucial needs in four areas:

- **Firefighting capacity—**Provide better models of weather, fire behavior, and 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-fuels reduction—**Develop improved analysis tools for determining the effects and economic tradeoffs of treatments intended to reduce fire risk by removing hazardous fuels (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.

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Introduction

Introduction

The National Fire Plan (NFP), initiated in 2001 in response to the devastating fire season of 2000 (table 1), helps to support the enhancement of much-needed fire management and fire research activities. The severe fire seasons of 2002 and 2003 (when over 3,000 structures were burned in southern California alone) reinforce the need for an aggressive and coordinated management response, and for the science needed to support it, including knowledge about fuel conditions that predispose landscapes to large uncharacteristically destructive wildfires. Over the past 3 years, the Forest Service and the Department of the Interior have made considerable progress in reducing hazardous fuels and assisting communities in preparing for fire. The Forest Service has accelerated efforts to improve the science base, analysis, and decision-support tools for fire and fuel management in its basic Research and Development (R&D) work as well as NFP research. National Fire Plan research and Forest Service R&D complement the research supported by the interagency Joint Fire Science Program and individual agencies—such as the U.S. Geological Survey, the National Aeronautics and Space Administration, the National Science Foundation, the National Oceanic and Atmospheric Administration—and other partners. A strong science foundation is key to predicting and managing hazards from wildland fire, improving the health of fire-adapted ecosystems, and supporting management decisions in the most cost-effective and environmentally sensitive way. Supported by scientific knowledge, decisionmakers are better equipped to forecast or prevent damaging fires and to understand the consequences of their decisions for society and for forest and rangeland health.

Table 1—Number of fires and burned areas as reported by the National Interagency Fire Center, 2000–2003[a]

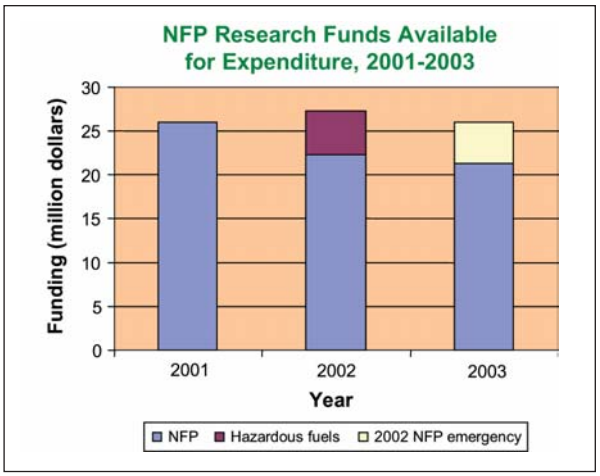
Date	Number of fires	Acres burned
2003 (Jan. 1 – Nov. 10)	57,637	3,815,952
2002 (Jan. 1 – Nov. 10)	70,140	6,734,211
2001 (Jan. 1 – Nov. 10)	76,055	3,396,363
2000 (Jan. 1 – Nov. 10)	90,420	7,250,708
10-year average 1993-2003	81,805	4,944,647

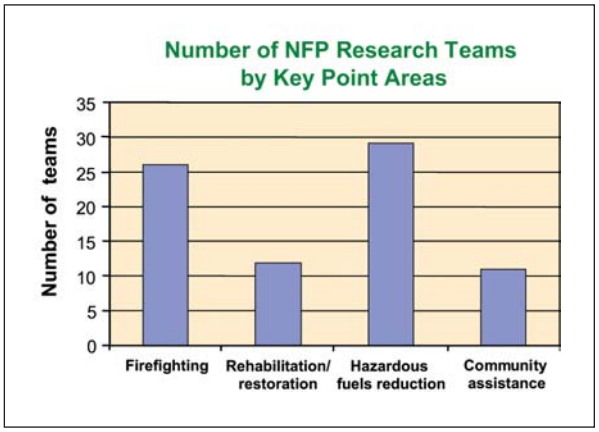
[a] This information is available online at http://www.nifc.gov.

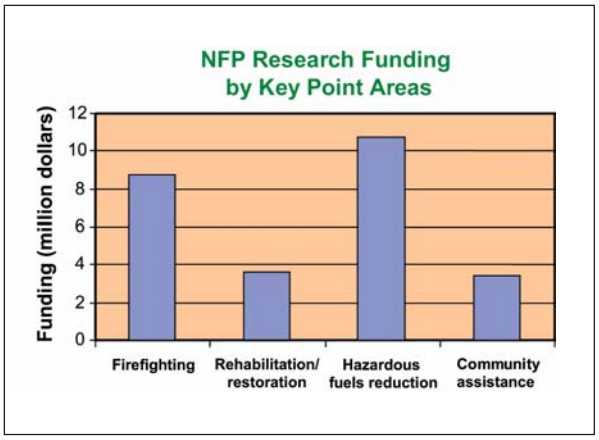
The benefits of NFP research are multifaceted. In addition to making research available through the standard research outputs of publications in journals, proceedings, and agency research papers, NFP teams focus strongly on outputs designed to meet the needs of those who make management and policy decisions. Over the past 3 years, NFP research funds have 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 and rehabilitation, and invasive species management.
- Evaluation of the effects of postfire treatments and fuel treatments.
- New tools and data to managers on active fire incidents.
- Development of new training materials and Web sites for disseminating information.
- Education for managers, policymakers, and citizens on related issues.
- Collaboration with universities and other key science partners.

Recent progress under NFP research is providing new information and tools to improve **firefighting** effectiveness, enhance **recovery** of burned ecosystems,improve programs for **hazardous-fuels reduction**, and enhance **community preparedness**.







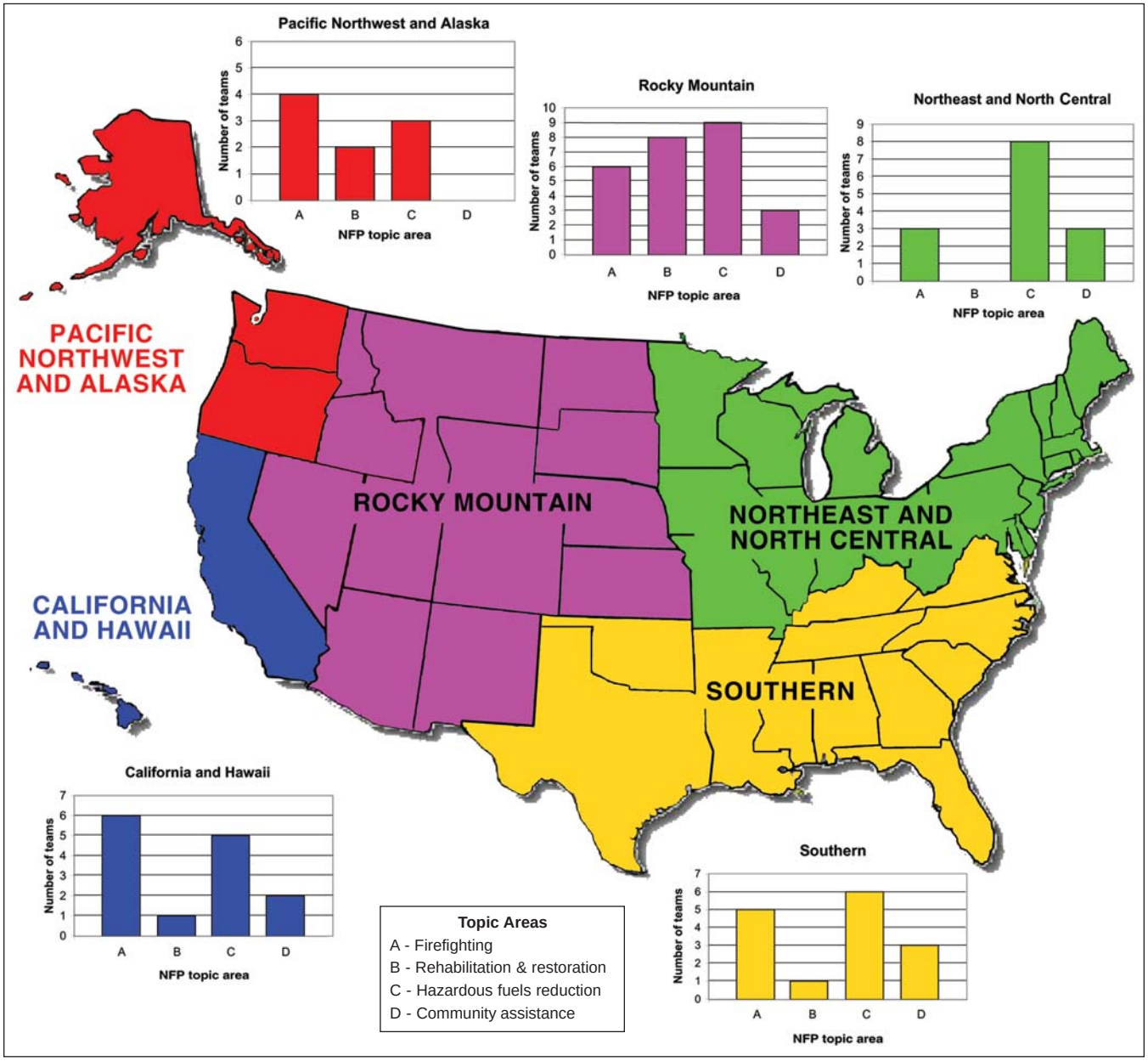
National Fire Plan Research Funding

Available funding for NFP research has remained relatively constant since 2001. However, the sources of this funding have varied from year to year. In fiscal year 2003, Forest Service R&D received a $21 million appropriation for the Forest Service NFP research program. In addition, $5 million in emergency funds, originally allocated for NFP research in fiscal year 2002, was released for spending in early 2003 and became available to support NFP research projects. Based on appropriation language for 2003, $1 million of program funds was allocated to the University of Montana Landscape Fire Center, $200,000 went to the University of Idaho to support the Fire Research and Management Exchange System project, and $390,000 was designated for national program support and special projects. The remaining $20 million (plus $5 million emergency funds) was distributed to research stations to support the 78 Forest Service NFP research teams. The number of research teams and funding amounts for the four key NFP areas are summarized in the graphs at the right.

Where Is National Fire Plan Research Taking Place?

The NFP research program is a national program that supports research in all 50 States, as well as Puerto Rico. The program attempts to balance priorities and funding to meet needs across the country in

terms of science support for the key points of the NFP. The research involves Forest Service research teams and many cooperators from universities, the private sector, and non-Federal agencies (see "appendix," table 4). The regional distribution of NFP activities across the country is illustrated below. It is important to note that research funding allocated to a team at a given location may support studies in other States or regions of the country. Many Forest Service research teams have broad national or regional missions and expertise, and research conducted at one location is often applicable across broad geographic areas.



Number of research teams in different regions of the country within each National Fire Plan (NFP) topic area.

Accomplishments

Accomplishments

This report summarizes the progress and accomplishments of the Forest Service National Fire Plan (NFP) Research and Development (R&D) in fiscal year 2003, the third year of NFP funding. It describes research findings, tool developments, technology transfer, and research highlights in four key areas:

- Firefighting
- Rehabilitation and restoration
- Hazardous-fuels reduction
- Community assistance

Improving our understanding of the ecological and social factors influencing fire regimes can provide insights into the vulnerability of different communities to wildfires.

Firefighting

National Fire Plan (NFP) research 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.

The following are NFP Firefighting Accomplishments for 2003:

- Scientists are working together in a regional consortium to develop improved means of predicting fire weather and smoke transport to enhance firefighting capability and fire preparedness. In cooperation with fire managers and fire-weather forecasters, many new and modified fire-weather predictive indices are under development and are being tested for potential implementation in operational weather-forecast models. These new indices will provide new tools for fire-weather forecasters to predict when atmospheric conditions will be conducive to extreme fire behavior (*Heilman et al., 01. NCS.A.1, North Central Research Station*).

- Improving understanding of the ecological and social factors influencing fire regimes can provide insights into the vulnerability of different communities to wildfires. Researchers completed and delivered a first-approximation fire regime map, ancillary data, and spatially explicit estimates of historical and current fire rotations to National Forest System fire managers in northern lower Michigan and Wisconsin. This information is assisting managers in allocating resources for firefighting and for identifying landscape ecosystem restoration opportunities (*Haight and Cleland, 01.NCS.A.2, North Central Research Station*).

- A stochastic fire generator was designed that incorporates potential natural vegetation, current and historical fire regimes, daily to multiannual climatology, and management

scenarios (application of thinning or prescribed fire). It allows for exploration of multiple scenarios for management, particularly prescribed/wildland fire tradeoffs, and climatic change for long-term projections of patterns of variability in regional haze—air pollution in the form of haze that travels long distances and reduces visibility and the quality of the viewing experience in scenic areas (*Sandberg, 01.PNW.A.2, Pacific Northwest Research Station*).

- Researchers are producing maps linking weather conditions and fire occurrence since 1895 and using this information to develop 3- to 12-month forecasts of burned areas. They developed a data set of observed fire area for the period 1986-1996 in the conterminous United States. This information will be used to verify trends in predicted fire area simulated by the continental-scale fire and ecosystem models (*Neilson, 01.PNW.A.3, Pacific Northwest Research Station*).

- 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. Scientists measured consumption and fuel conditions on four wildland fires and two prescribed fires in Alaska to improve model predictions of fire severity. The findings will enable managers to make better predictions of fire danger and fire severity involving residual combustion, fire effects, and the opportunities for fire use (*Sandberg, 01.PNW.A.4, Pacific Northwest Research Station*).

- Researchers are developing a model to simulate alternative scenarios for initial response of suppression resources to wildfires ("initial attack"). This model takes advantage of new computing technology to make realistic estimates of the time required for firefighters to reach a fire from various locations where resources may be available. The new model will assist fire managers in quickly exploring options and identifying with greater certainty the best levels of investment in fuel treatments, prevention, and initial-attack programs (*Wiitala, 01.PSW.A.2, Pacific Southwest Research Station*).

- To better understand and model combustion processes in live vegetation, researchers successfully characterized the behavior of live chaparral fuels (chamise, manzanita, scrub oak, and ceanothus) by examining flame height, temperature field, and mass loss rate when fuels were burned in a cylindrical container. With this information, managers will be better able to anticipate fire risks (*Weise, 01. PSW.A.3, Pacific Southwest Research Station*).

- Forest Service research is using a recently developed thermal imaging radiometer (FireMapper) to accurately monitor active wildfire progression and intensity from aircraft, and rapidly transmit fire information to incident management groups via a combination of satellite phone and the Internet. The system, which also includes on-board computers, geopositioning, and auxiliary digital cameras, provided near-real-time data in 2003 on fires in Montana and southern California. The FireMapper system also was used to map the

A recently developed thermal imaging system provides information to evaluate and improve fire behavior models, improve firefighting safety, make firefighting more effective, and reduce wildfire damage to natural resources and society.

distribution and progress of tree mortality in control areas near homes and communities in California's San Bernardino Mountains. Maps are readily accessible over the Internet. This new system is providing information to evaluate and improve fire behavior models, improve firefighting safety, make firefighting more effective, and reduce wildfire damage to natural resources and society (*Riggan, 01.PSW.A.4, Pacific Southwest Research Station*).

Researchers established the capability to routinely retrieve, process, and store real-time satellite data to provide daily maps of active fire locations and growth of fires at 1-km resolution...

- Daily information on fire locations and burned areas is compiled from ground surveys and is not reported until the following day. Researchers established the infrastructure and capability to routinely retrieve, process, and store real-time satellite data. This automated system provides daily maps of active fire locations and growth of fires at 1-km resolution in most of the continental United States and is being used to predict fire behavior and the potential threats of fires on communities and electrical power lines (*Hao, 01.RMS.A.2, Rocky Mountain Research Station*).

- Assessing the severity of the upcoming fire season is key to efficiently allocating fire-suppression resources. A cooperative agreement was initiated with the School of Computational Sciences and Information Technology at Florida State University to evaluate the performance of physics-based fire-dynamics models to assess their applicability to southern fuel/weather conditions. These sensitivity studies will help guide long-range forecasting toward those parameters most critical to fire behavior in the South (*Goodrick, 01.SRS.A.4, Southern Research Station*).

- Nitric acid (HNO_3) is a pollutant resulting from forest burning that may be toxic to humans and plants. Because of its rapid deposition, HNO_3 contributes large amounts of nitrogen to forest ecosystems, in extreme cases causing saturation of forests with nitrogen and contamination of groundwater and streams. Scientists developed a passive sampler for HNO_3 vapor to monitor HNO_3 vapor and improve modeling of smoke contributions to regional haze in the remote locations in the Western United States (*Bytnerowicz, 02.PSW.A.1, Pacific Southwest Research Station*).

- 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 burned areas of large fires 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 and will help land managers plan for and conduct prescribed burns while complying with air quality standards. Regional Haze Rule is a new U.S. Environmental Protection Agency rule promulgated under court order requiring that 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 requirements and that the effects of fires on air quality be evaluated (*Hao, 02.RMS.A.2, Rocky Mountain Research Station*).

- Researchers are developing mobile instruments that can do real-time measurements of particulate concentrations emitted by fires over a large area. 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 (*Hao, 01.RMS.A.3, Rocky Mountain Research Station*).

- Costs of suppressing wildfires are increasing over time, along with total suppression costs on Federal lands. Collaborative research with North Carolina State University seeks to quantify the effectiveness of suppression resources on fires nationwide. Preliminary results show how firefighters and equipment (air and ground) affect the amount of damage observed. The goal of this research is to better understand how to minimize the costs of suppression and fire-related resources and economic losses from large wildfires (*Prestemon, 01.SRS.A.2, Southern Research Station*).

Costs of suppressing wildfires are increasing over time, along with total suppression costs on Federal lands...[Research is helping to] better understand how to minimize the costs of suppression and...economic losses from large wildfires.

- A study was begun on the effect of differences in canopy cover at the home-range scale on reproductive success of California spotted owls. This analysis used previously published data from southern Sierra Nevada to examine how different amounts of low-, moderate-, and high-density canopies affected the annual recruitment of owls, after adjusting for population-level trends. The study illustrated the use of influence diagrams (graphical models that show the relationships among decisions elements such as decision alternatives, chance events and outcomes, and consequences) for comparative risk assessment and indicated that fuel treatments in some areas might be expected to have no measurable effect on owl reproduction (*Lee, 01.PSW.A.1, Pacific Southwest Research Station*).

- Wildfire resource deployments and prescribed burn go/no-go decisions depend on past, present, and predicted weather at the event location. Although programs for past and present "spot" forecasts provided by the National Weather Service are site specific, they do not provide the level of detail that state-of-the-art systems can produce. The Rocky Mountain Center provides user-friendly, up-to-the-hour analysis and forecasting of fire weather, using the Local Analysis and Prediction System. This tool supports all weather-related fire management needs (*Zeller, 02.RMS.A.1, Rocky Mountain Research Station*).

Firefighting Highlight

Reducing Risks and Protecting the Public

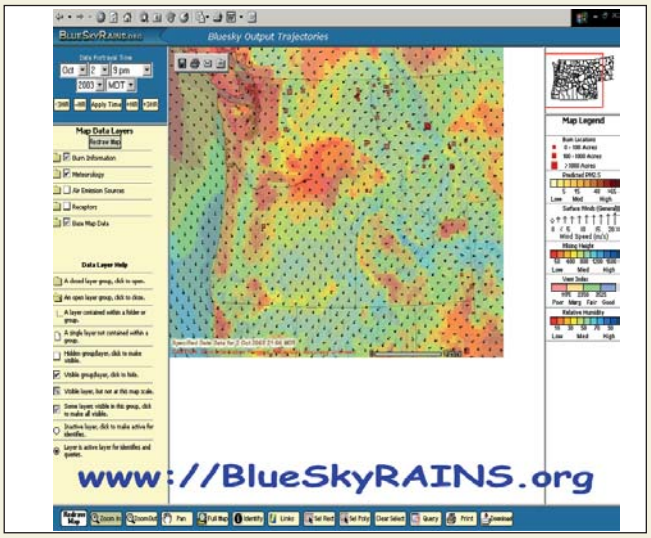
Fire Consortia for Advanced Modeling of Meteorology and Smoke

Background: We can improve firefighter safety and fire management by better understanding fire weather and smoke. Scientists in five Forest Service research stations are working cooperatively to develop a nationally consistent program of consortia, Fire Consortia for Advanced Monitoring of Meteorology and Smoke (FCAMMS), for simulating fire weather and predicting its short-term development. Each of five regional consortia is a multiagency coalition of researchers; fire managers; air-quality managers; and natural resource managers at the Federal, State, and local levels.

The mission of FCAMMS is to:

- Increase understanding of fire weather; fire danger; fire behavior; and the transport, diffusion, and impact of smoke from fire.
- Develop and implement new technologies related to regional fire weather and air quality (e.g., satellite-based, real-time smoke emissions).
- Enhance ability to use fire for land management purposes.
- Improve tools for firefighters to better predict and respond to the dangers of wildfire.

Approach: Key to the success of FCAMMS is collaboration between science and management. The members of the ideal FCAMMS include government and university research scientists; analysts; operational forecasters; information officers; and representatives from private, State, and Federal agencies concerned with fire weather and smoke. An overarching organizational structure allows administrators, field personnel, and scientists to work together to meet user needs and requirements. At the core of the products provided by the FCAMMS is output from high-resolution meteorological simulation models such as the Pennsylvania State University/National Center for Atmospheric Research mesoscale model (MM5) and similar models. Research scientists use these models, along with ancillary behavior and smoke dispersion models and remote sensing data, to provide forecasts of probable fire-weather or smoke conditions to meet operational data needs. They also use the models to study and better understand how the atmosphere and fires or smoke interact, thereby improving the value of the model results and fire-weather or smoke-dispersion tools for their users. This type of science-management collaboration allows a small number of researchers to provide data and develop products that are potentially useful to a large number of users. Different regions of the country have different smoke- and fire-related weather products needs. This regional approach combined with their user-scientist collaborative approach enables FCAMMS to better meet fire and smoke management needs of each region of the country.



The Northwest Modeling Consortium, a cooperative effort between the U.S. Environmental Protection Agency, the University of Washington, and the Pacific Wildland Fire Sciences Laboratory, is producing real-time forecasts of smoke from prescribed fire and wildfires. BlueSkyRAINS is a research product linking wind and smoke emissions being adapted for use by the Fire Consortia for Advanced Modeling of Meteorology and Smoke nationally.

Products: Products developed include:

- **High-resolution weather information**. While the National Weather Service continually upgrades observations and model data for its forecasters, access to locally focused model results (at 4-km or smaller resolution) provides firefighters with more accurate detailed winds around topographic features.
- **Fire indices.** Researchers have developed a set of indices useful for forecasting fire weather, fire danger, extreme fire behavior potential, and seasonal fire risk.
- **Smoke predictions.** The BlueSky smoke framework links weather model outputs with fire emissions to project where smoke will go and how it may impact the public. Information from the National Aeronautics and Space Administration's Moderate Resolution Imaging Spectroradiometer (MODIS) instruments is being used for fire location and near real-time fire emission inventories and is being linked with weather simulations.
- **Fire-behavior models.** Terrain-gridded weather simulations are now being used as a primary input for spatial fire behavior models, which are used for predictions of fire spread and intensity to protect people, structures, and resources.

Application: FCAMMS are helping firefighters do their jobs more safely and effectively by providing timely, high-resolution, meteorological data good for up to 72 hours into the future to:

- Burn more safely by planning prescribed fire with relevant weather information.
- Burn more effectively by identifying additional burning or treatment windows.

Firefighting Highlight

- Burn cleaner and reduce air-quality problems by developing and applying better smoke management tools.

FCAMMS are helping air-quality officials understand and properly attribute the contribution of forest fire smoke to ambient air quality by using "best smoke management practices" tools. This year, through the efforts of FCAMMS, the BlueSky smoke modeling system became operational in the Northwestern United States, southwestern Canada, California, and central and southern Rocky Mountain regions. The system consists of a flexible framework for obtaining information on the impacts of smoke by integrating fire location, forest fuels, geographic information, outputs from meteorological simulations, and air-quality dispersion models to illustrate where smoke will go and how much of it will get there. The BlueSky model predicted smoke impacts from hundreds of wildfires and prescribed fires in eight States and two provinces. Incident command teams and air managers used the predictions to anticipate impacts, warn surrounding communities of impending hazards, and help plan aerial attacks for wildfires. Air regulators used BlueSky to coordinate burn activities across land ownerships for prescribed fires. The BlueSky prototype is being evaluated by all the FCAMMS for implementation nationwide. Additionally, FCAMMS will allow access to state-of-the-science models such as the U.S. Environmental Protection Agency Community Multiscale Air Quality Model for regional haze and air-quality standard assessments.

FCAMMS is advancing fire science through basic and applied research on new fire-weather and fire-climate indices, predicting seasonal fire severity, small-scale fire-atmosphere interaction dynamics, remote sensing to detect smoke, smoke transport and diffusion, and coupled fire-atmosphere modeling. Each regional consortium produces daily predictive simulations of fire-weather and transport/diffusion variables by using a common set of modeling tools, available in almost realtime via the World Wide Web (http://www.fs.fed.us/fcamms). Users can tailor map products and analyses depicting current and future atmospheric conditions relevant for fire weather, fire behavior, and smoke. These products are already being used by fire managers and fire-weather meteorologists in many regions to aid them in making decisions about daily firefighting activities, as well as for planning prescribed burns. FCAMMS is committed to learning how well these products work by validation through feedback from user communities and field tests.

The southern FCAMMS-SHRMC, a cooperation between the University of Georgia and the Forest Service Southern Research Station, produced this 12-km resolution MM5 simulation of surface relative humidity, winds, and surface pressure at 12Z, August 28 for 24 hours ahead.

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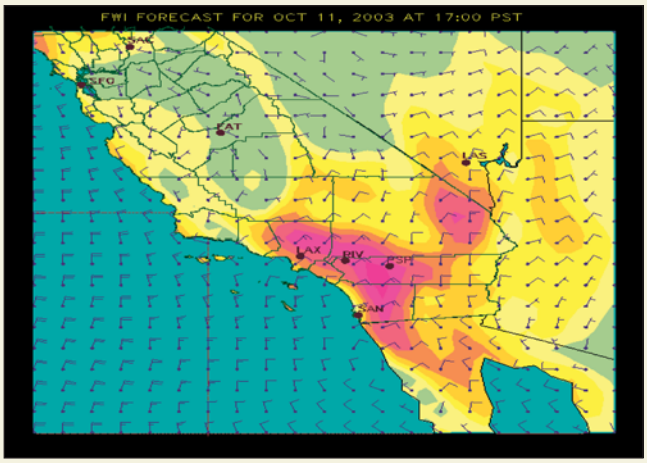


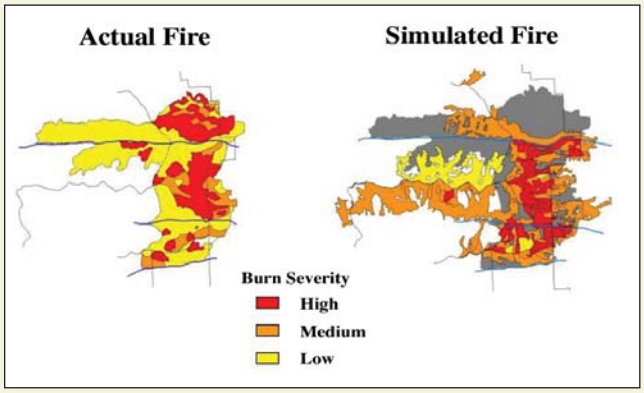
Firefighting Highlight

Improving Decisions for Fuel Treatment Options

Background: Two decision-support tools, SIMulating Patterns and Processes at Landscape ScaLEs (SIMPPLLE) and Multiresource Analysis and Geographic Information System (MAGIS), are being developed to (1) analyze the extent and likely location of fire, insects, and diseases both in the presence and absence of treatments; (2) develop treatment alternatives for addressing fuels treatment along with other resource objectives; and (3) evaluate those alternatives in a way that captures the combined effects of treatments and disturbance processes.

Approach and Products: Maps and charts are developed to illustrate the modeled distribution of fire (across the modeled landscape treatments) and other selected disturbance processes. Economics of treatments are evaluated by comparing fire-suppression costs with and without treatments with treatment costs and revenues (if any). This year the ArcGIS software extension for SIMPPLLE was completed allowing the user to easily map SIMPPLLE simulation results with the latest geographic information system (GIS) software. New fuel treatment logic in SIMPPLLE was tested for use in management plan revision. Two fine-scale fire growth simulation models, FARSITE and Forest Vegetation Simulator (FVS), with the fire and fuels extension, are being used to improve the representation of fire processes within SIMPPLLE. Design for both MAGIS Professional and eXpress was completed in cooperation with the Forest Service Inventory and Monitoring Institute and the University of Montana. The final design includes user interfaces for data checking and input, model and scenario specifications, output display, and an interactive tool for scheduling fuel treatments and other activities. MAGIS eXpress version 1.1 and MAGIS Professional versions also include a number of features requested by field personnel and geospatial integrity checks, in addition to the new GIS interfaces. New and updated screens for managing program variables (attributes) also have been added, making the modeling process easier to understand. In cooperation with the University of Montana, work has begun on a heuristic solver for MAGIS eXpress that will be much easier for field personnel to use than the current mathematical programming solver.

Four new agreements were entered with cooperators, 1 new contract was completed, 4 publications were completed, 4 presentations were made at scientific conferences, 14 demonstrations were done, and 7 significant consultations occurred.



Blodgett trailhead fire compared to the fire simulated with SIMPPLLE.

Application: Work is underway with a number of cooperators to test and evaluate these models on nine planning areas representing a variety of fuel types found on public lands across the United States. These models also are being used by the Bitterroot Ecosystem Management Research Project in cooperation with the Bitterroot National Forest to plan fuel treatments. In addition, SIMPPLLE was used to evaluate fuel treatment scenarios on a 400,000-acre area in the Swan Valley in cooperation with the Forest Service Northern Region (R-1) regional silviculturist and the assistant fuels director. The SIMPPLLE tool is being used by R-1 for project planning and forest plan revision, by the Montana field offices of the Bureau of Land Management, and by an environmental consulting firm for broad regional assessment.

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Key Partners:

Rocky Mountain Research Station units: RWU-4802, RWU-4151, RWU-4654 (Bitterroot Ecosystem Management Research Project), RWU-4653, RWU-4401, and RWU-4403
Pacific Southwest Station units: RWU-4402, RWU-4403
University of Montana
Forest Service Inventory Monitoring Institute
Forest Service Northern Region
Carroll Nelson and Associates
Geo Data
Systems for Environmental Management
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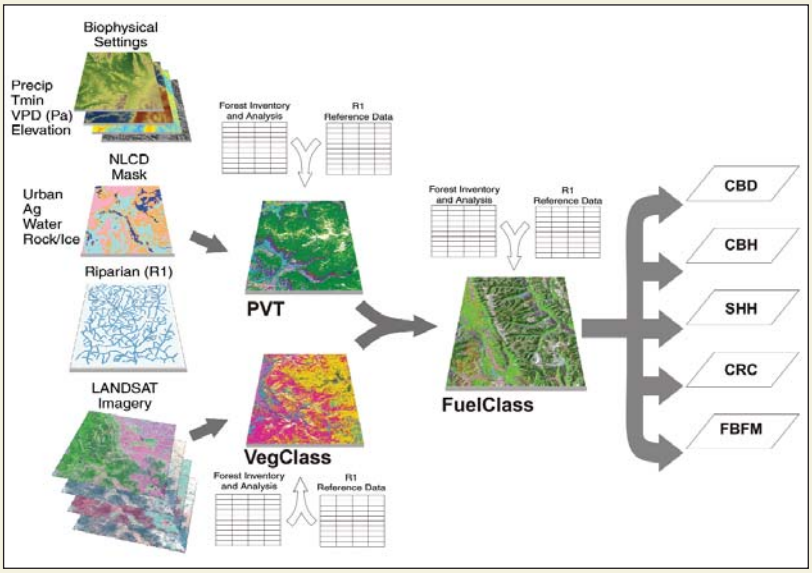
Bureau of Land Management, Montana State Office

Firefighting Highlight

Remote Sensing, Geographic Information System, and Landscape Assessment Tools for Fire Management

Background: In August 2003, scientists at the Missoula Fire Sciences Laboratory were asked to support the Northern Rockies Multiple Agency Coordination (MAC) Group in evaluating potential fire activity for 33 large fires, managed by 4 area command teams. The MAC group needed a quick way to create the fuels and vegetation structure data required to implement FARSITE, a fire area simulator, for predicting the spread and behavior of fires as a planning tool. Data and methods from the ongoing Northern Rockies LANDFIRE prototype were applied in managing these rapidly spreading, severe fires.



A modified LANDFIRE approach used for creating FARSITE layers for the Northern Rockies Coordination Group, August 2003.

Approach: An adapted set of LANDFIRE protocols was used to develop the geospatial inputs for FARSITE. The LANDFIRE fuels mapping protocols integrate extensive field reference data, remotely sensed imagery, ecosystem simulation, and biophysical gradient modeling to create maps of vegetation condition and fuel characteristics. Overlap between the Northern Rockies LANDFIRE prototype area and MAC area of operations created a unique opportunity to use the LANDFIRE reference database and biophysical modeling approaches to provide an immediate product for fire management and planning.

Products: Creation of 30-meter resolution FARSITE fuel maps incorporated three main LANDFIRE databases:
Reference data–Data extracted from the LANDFIRE reference database. Consisted primarily of Northern Region ECODATA and forest inventory and analysis plot data. Information on fuels and vegetation condition was derived for each plot by using the FIREMON analysis package, a fire effects monitoring and inventory protocol.
Potential vegetation types–Created by classifying mapped topography, climate, and ecophysiological information by using classification and regression trees.
Existing vegetation–A maximum likelihood fuzzy approach was used to classify Landsat 5 and Landsat 7 satellite imagery from summers 2002 and 2003 for the MAC group's area of operations.

Potential vegetation and existing vegetation were combined, and different combinations were assigned fuel models and structural characteristics required by FARSITE. This is the main departure from the LANDFIRE method where structure is mapped separately and incorporated explicitly during the fuel mapping process. For example, researchers created separate fuel models for mesic montane shrub and herbaceous vegetation and upper subalpine shrub and herbaceous vegetation, each based on the Anderson fuel model 5 (a fire model used to predict fire behavior in a montane shrub type).

Application: The resulting fuels data were applied in several FARSITE simulations at both regional and local scales under an array of fire-weather conditions. The results of these simulations aided the MAC group in strategically planning for rapidly developing incidents across the area of operations. In some cases, the simulation results were used to pre-position resources and pretreat areas where specific values were at risk. Simulation results showed that fuels mapped with the modified LANDFIRE approach more accurately portrayed the behavior of real fires than the existing fuels data based on national forest stand maps.

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U.S. Geological Survey
Forest Service Pacific Northwest Research Station
University of Montana
Systems for Environmental Management
Forest Service Forest Inventory and Analysis
National Aeronautics and Space Administration

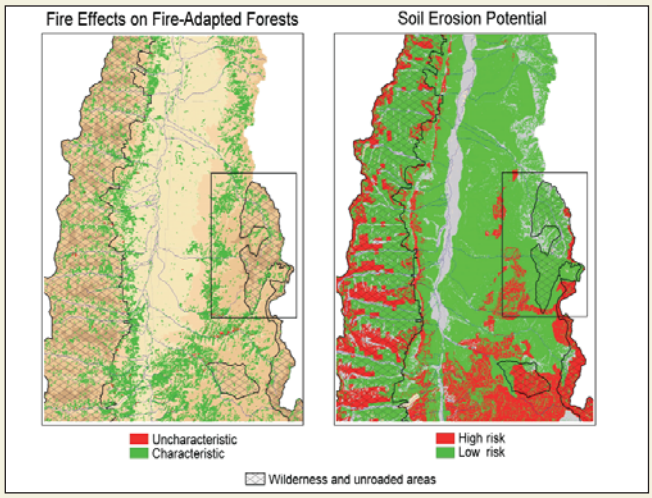
Firefighting Highlight

Identifying the Benefits and Risks of Fire Improves Planning

Background: Wilderness and other unroaded areas serve an important and unique role in the management of fire within larger landscapes. These areas provide the greatest opportunity for learning how to use lightning-ignited fires as a cost-effective strategy for thinning forests, reducing accumulated fuels, and restoring the natural role of fire to ecosystems. Currently, most lightning ignitions in large unroaded areas are suppressed because of the risks fires might pose to a variety of social and ecological values. Suppressing fire reinforces a feedback cycle where fuels continue to accumulate, risk escalates, and the tendency to suppress fires continues. Existing decision-support tools focus only on the negative consequences of fire. To make effective decisions regarding fuels and fire, managers need to assess the benefits of fire use along with its risks, as well as the consequences of continued fire suppression. Without information on the benefits of fire, the justification for using wildland fire as a management strategy is severely limited.

Approach: Our geographic information system (GIS)-based protocol uses available data and computer tools. A weather analysis tool (FireFamilyPlus) is used to summarize local fire weather data in terms of threshold conditions (i.e., 87th, 90th, and 97th percentile fire danger ratings). Spatial data on fuels and the summarized weather data are then put into a spatially explicit fire behavior model (FlamMap), which is used to generate a library of GIS maps that identify fire behavior parameters (such as crown fire activity) under different fire weather threshold conditions. This generates information about the current landscape. To consider future conditions, landscape dynamic simulation models may be used to generate potential future landscapes and fuels profiles. Map libraries of first- and second-order fire effects are then generated from these fire behavior parameters by using existing tools such as First Order Fire Effects Model (FOFEM) or the Water Erosion Prediction Project model (WEPP), or from locally developed, rule-based algorithms such as species-habitat relationships.

Products and Tools: Rocky Mountain Research Station scientists at the Aldo Leopold Wilderness Research Institute in Missoula, Montana, are trying to break the feedback cycle between fire and fire suppression. During fiscal year 2003, they developed a protocol for managers to use to identify key areas of fire risk and systematically determine where and under what conditions fire will benefit ecological conditions while reducing fuels. Information about fire weather, vegetation, and fire behavior is used to build a library of maps that display the expected fire behavior under critical fire-weather conditions and resulting effects on different social and ecological values. These maps can be used to identify areas where opportunities exist for achieving resource benefits on a wildfire incident, as well as to monitor and report progress toward land management goals. An important feature of this protocol is that fire effects are expressed in terms meaningful to both fire managers and land managers, thereby bridging a common communication gap that exists between those two groups.



Two maps from the library generated for the Bitterroot National Forest of expected effects on soil erosion and fire-adapted forests from a burning under moderate weather conditions. Together with other maps in the library, these maps identify areas where managers can safely allow fires to burn. For example, within the highlighted area, fires are likely to have substantial ecological benefits with few adverse impacts.

Application: The library of maps generated by this protocol is being used by managers at the Bitterroot National Forest in western Montana to update and develop new guidelines for their fire management plan. In addition to providing them with planning and tactical assistance, local fire management officers will use the map library as a valuable public communication tool. The national forests in the Northern Region's Western Montana Planning Zone also are planning to use the protocol. For instance, the Beaverhead-Deerlodge National Forest will use the protocol during their upcoming forest plan revision to project how the addition of wildland fire use zones could affect critical forest resources in the future. This research is providing a way for managers to classify potential fire effects into beneficial vs. detrimental categories, and is helping them decide where and under what conditions fires can be allowed to burn. With better informed decisions, managers can focus suppression resources where fires pose clear risks and avoid costly expenditures where fires confer resource benefits.

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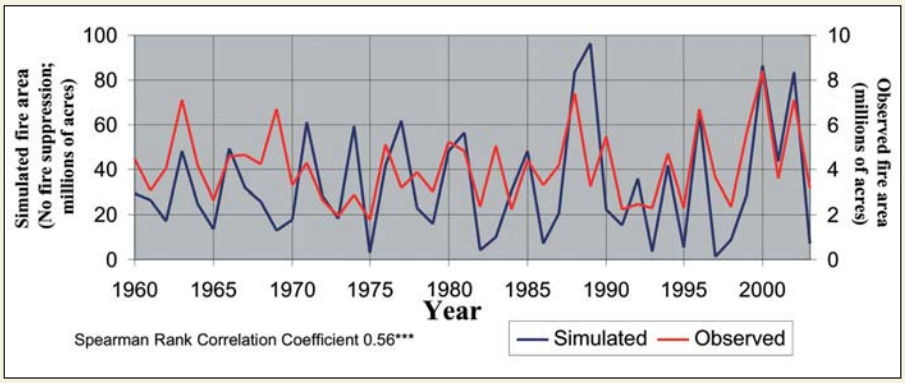
Key Partners:

Bitterroot National Forest, Beaverhead-Deerlodge National Forest Northern Region Western Montana Planning Zone

Firefighting Highlight

Forecasts and Applications in the 2003 Fire Season



MC1 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.

Background: Recent fire seasons have been unusually severe and expensive in terms of firefighting costs, as well as loss of life and property. Forewarned is forearmed in terms of how much to allocate for firefighting, where to locate the firefighting resources, and where fuel reduction activities might be most effective. Ideally, forecasts of fire risks would project out 2 or 3 years, but even a few months warning is helpful. Increased fuel loads, owing to a century of fire exclusion, have traditionally been thought to be the cause of recent large fires. However, climate variability is now increasingly considered to have had a large role in the recent fire patterns. Thus, fire forecasts must be balanced by historical analyses of fire-climate interactions to understand the present fire situation and how to prepare for both the near- and the long-term future. Fire area in the West has been strongly related to the Palmer Drought Severity Index (PDSI), following two interdecadal wet-dry cycles since the mid-1970s. The recent climate variations are related to El-Niño/La-Niña cycles and various oceanic interdecadal oscillations, with climate regime shifts in the mid-1940s, 1970s, and from 1988 through 1989. The West is in one of the worst droughts of the century, following fuel buildup during strong wet cycles, a pattern that appears to have fostered much of the recent severe fire situation.

Approach: Retrospective analyses are made possible through gridded weather observations dating from 1895 to the 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 in the United States over the last four decades, even without accounting for fire suppression. Both observed and simulated fire areas over the United States declined slightly from 1960 to 1988, but have increased dramatically since then. Forecasts for the 2003 fire season were updated monthly, based on three 6-month coupled ocean-atmosphere climate model forecasts. Observed fire activity in the 2003 fire season was remarkably coincident with the simulated distribution of fire risk and was relatively low compared to recent years.

Products and Tools: The Mapped Atmosphere-Plant-Soil System (MAPSS) Team 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 model, MC1, is ideally suited for seasonal fire danger forecasting and for analyzing historical climate-fire interactions. The team is publishing on the World Wide Web experimental 6-month fire-risk forecasts to better anticipate firefighting and management needs (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.

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Key Partners:

Oregon State University, Spatial Climate Analysis Service
The Program for Climate, Ecosystem and Fire Applications: a collaboration between the Desert Research Institute and the Bureau of Land Management National Office of Fire and Aviation
International Research Institute for Climate Prediction (Columbia University)
SCRIPPS Institution of Oceanography

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