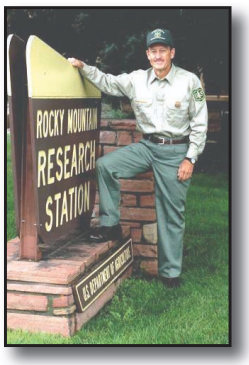
USDA Forest Service
Rocky Mountain Research Station

Research Accomplishments 2007

Cover photo: Dubbed the "Red Hand of Death," this 2006 snapshot of mountain pine beetle infestation on the Station's Fraser Experimental Forest in central Colorado, shows old-growth lodgepole pine (red) that has succumbed to bark beetle attack. Green stands are 50-year-old subalpine forests regenerating within clearcuts. This is the managed portion of a study designed to evaluate how harvesting affects water yield and quality. The un-manipulated control basin appears in the background. Heavy overstory mortality in these and other watersheds at Fraser provides scientists with an unprecedented opportunity to assess the consequences of bark beetle outbreaks on subalpine forest watersheds. Learn more about studies at the Fraser Experimental Forest by visiting www.fs.fed.us/rm/fraser.

From the Director

This past year has been a period of transition for the Rocky Mountain Research Station. In 2006, we identified the need to move from an organization of approximately 30 research work units whose work was formed around national Strategic Program Areas, to a more streamlined team-oriented organization composed of Science Programs and Research, Development, and Application programs (RD&A's). Much planning, study, and employee input went into how the new Station would be configured and managed.



On January 27, 2007, we flipped the switch on our new organization. For the last year, the new Leadership Team and various employee task forces have been working through the details of implementing the new Station. Despite the inevitable difficulties of organizational change, the Station's magnificent research productivity has not slowed. As this accomplishment report clearly shows, the Rocky Mountain Research Station's Science First! Teams are very much alive and kicking out exciting and useful findings and tools.

Our new structure will make us more flexible and resilient so that we can respond to changing budgets, political shifts, massive environmental and economic events, and a host of other drivers that are changing the way we do business, now and in the future. We are moving from a hierarchical structure with Station headquarters at the top, to a managed science network, connected by a Leadership Team that integrates science into management decisions and connects to partnership and user networks to extend our impact and our science application capabilities. Just as an ecosystem's resilience depends on the diversity and connectedness of its populations and communities, we are becoming a Station that is better networked and activated to unlock the secrets of a changing Interior West.

The new Rocky Mountain Research Station will allow us to deliver a wide array of science findings and services across our four Forest Service Regions, Agency territories, and states. We will also be able to present our science to users in a more simple and straightforward manner. In addition, the process of planning and chartering new Science Programs and RD&A's will allow us to interact with a broader range of stakeholders, emphasize integration across disciplines and Station geography to contribute to positive outcomes on the ground, and align science direction with Agency and Station goals.

As our scientists and support personnel transform into new roles and responsibilities, we are confident that their future efforts will result in breakthroughs in the science of managing sustainable systems. We are building an integration framework that will guide investments and add value to the capacity and creativity of the Station's talent that you see in these pages. This framework will direct Station resources to critical questions and science gaps in understanding key drivers of change (population and climate change interactions), their effects on changing landscapes (primarily through fire, invasives, and related events in disturbance systems), and the unique blends of ecosystem services

(primarily water and the human connections to nature) that define the Interior West and its conflicts and potentials. As our accomplishments show, we are making significant contributions to each of the components. The next steps will be to enhance these efforts and bring them together in landscape and watershed systems to create knowledge tools for managing systems, not just system parts.

While we have taken a new approach to doing research and created a different looking and operating organization, our bottom line of delivering the best science to our customers remains the same. The central mission of RMRS—producing sound science and enabling the innovative problem solving that flows from it—has not and will not change under our new organizational structure and management processes. As you read the accomplishments of 2007 and those in future years, you will see that we are striving to capitalize on our unique research capabilities, and to better serve the dynamic needs of our ultimate customers, the American taxpayers and their natural resources.

David A. Cleaves

Station Director

(In January 2008, Station Director Dave Cleaves transferred to the Forest Service's national headquarters in Washington, D.C. to serve as Associate Deputy Chief for Research and Development. Dr. George S. (Sam) Foster is the new Director of the Rocky Mountain Research Station. He comes from the Agency's Washington, D.C. headquarters where he served as Director of the Resource Use Science Research Staff. His career has been devoted to natural resources work, serving for over 16 years with the US Forest Service. He also held the positions of Dean of the College of Forest Resources and Director of Forest and Wildlife Research at Mississippi State University. He earned a BS in Forest Management and a MS in Forest Genetics and Silviculture from the University of Tennessee, and a PhD in Forest Genetics and Silviculture from Oregon State University.)

Contents

A Look at RMRS

The Rocky Mountain Research Station is one of five regional units that make up the USDA Forest Service Research and Development organization – the most extensive natural resources research organization in the world. We maintain 12 field laboratories throughout a 14-state territory encompassing the Great Basin, Southwest, Rocky Mountains, and parts of the Great Plains. The Station employs a diverse workforce of approximately 500 permanent full-time employees, of which one-fifth are research scientists.

We administer and conduct research on 14 experimental forests, ranges and watersheds, while maintaining long-term databases for these areas. We also oversee activities on more than 260 Research Natural Areas (http://rna.nris.state.mt.us) and lead four ecosystem management and research partnership projects in Arizona, Colorado, Montana, New Mexico, and Nevada.

Our research program serves the Forest Service as well as other Federal agencies, State agencies, international organizations, private groups, and individuals. Research results are made available through a variety of technical reports, journals, and other publications, seminars, symposia, demonstrations, exhibits, and personal consultations. These help resource managers and planners balance economic and environmental demands for forest and rangeland resources worldwide.

The Forest Service Research and Development mission—"develop and deliver knowledge and innovative technology to improve the health and use of the nation's forests and rangelands"—guides the work we do. Our priorities are to:

- Create credible, innovative, science-based solutions for resource management problems.
- Identify relevant needs and quickly and efficiently convert science gaps into findings and products for managers and citizens.
- Anticipate and respond to emerging issues.
- Enhance the ability of our customers and partners to more easily find, participate in, and use products of the RMRS research program.

Our employees are guided by the Station's mission—"to develop and deliver scientific knowledge and technology that will help people sustain our forests, rangelands, and grasslands.

Communicating with Stakeholders

Credible, useable, and effective scientific information is our product. We recognize that the scientific information we produce must be packaged, promoted, and delivered so that our stakeholders can understand it and use it effectively. As we disseminate information, we solicit feedback as to its relevance and usefulness, monitor the success of our communication efforts, and adapt strategies as needed.

Administration and Support Services Staffs

The success of our research programs would not be possible without the critical team support provided by our nearly 400 administrative and technical employees. Most are located at Station headquarters in Fort Collins, Colorado, and at the Ogden, Utah, Service Center; others work at laboratory locations. These staffs include: Civil Rights; Budget; Public Affairs; Science and Technology Applications; Acquisition Management; Facilities Management; Financial Management; Library Services; Publishing Services; Web Services; Safety, Health and Environment; Senior, Youth and Volunteer Program; and Statistics. The Station also receives administrative support from the Albuquerque Service Center.

Partnerships

To help advance solutions to pressing natural resource problems, the Rocky Mountain Research Station maintains key partnerships with:

National Forest Systems. Forest supervisors and managers compose the Station's largest customer segment or stakeholder group. The Station supports several national missions, including the Fire Sciences Laboratory and the Aldo Leopold Wilderness Research Institute, both in Missoula, Montana. National Forest Systems rely heavily on Station staffs to provide scientific information and assistance in implementing the Endangered Species Act, Clean Water Act, Clean Air Act, and other environmental legislation.

Researchers sponsor field trips for resource managers to explain the benefits of science findings.

Other Federal Land Management Agencies. The Station serves managers of the largest public land holdings in the lower 48 states, including the Bureau of Land Management, National Park Service, Bureau of Reclamation, and Department of Defense.

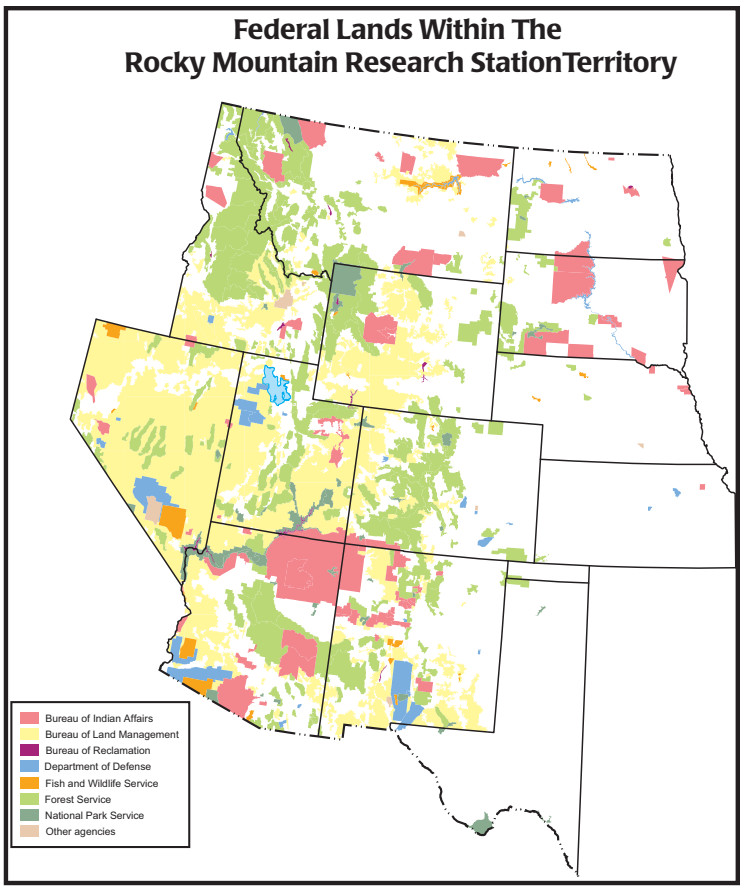
Other Federal Non-land Management Agencies. We provide regular consultation to the Environmental Protection Agency, National Marine Fisheries Service, U.S. Fish and Wildlife Service, Natural Resources Conservation Service and Bureau of Indian Affairs in non-land management functions.

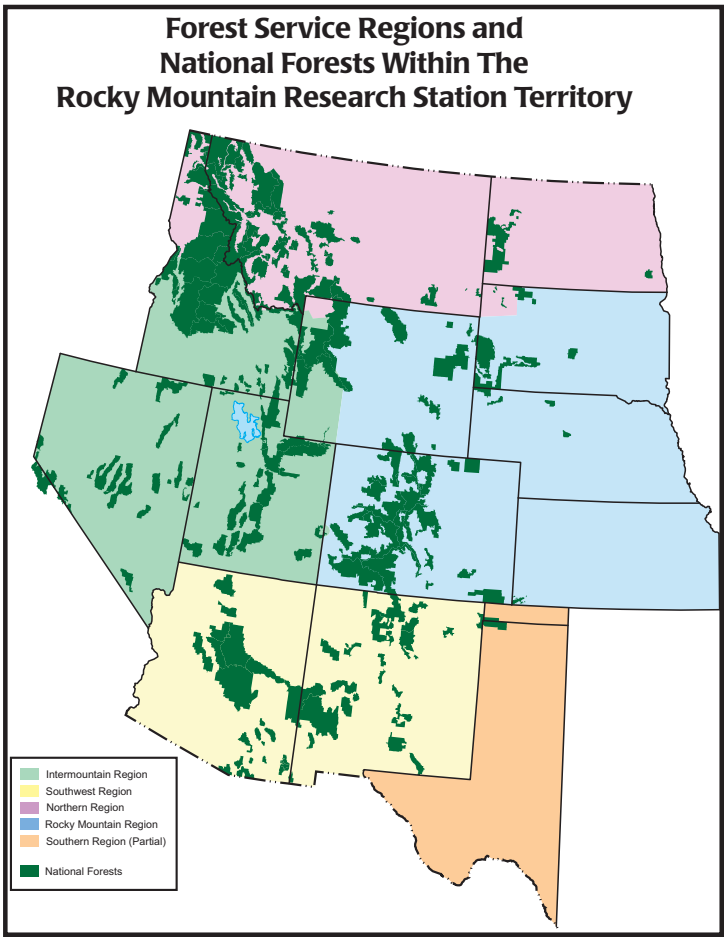
State, Local and Other Public Agencies. Our Interior West Resource Inventory unit is the Station's largest unit and provides eight Western States with resource inventory and monitoring data for use by State, County and urban planners, State resource agencies, industry, and others.

Industry. The forest products industry is an important customer for tree improvement, forest productivity, insect and disease, and engineering technology research. We collaborate with the Forest Products Laboratory in Madison, Wisconsin, to link utilization researchers with forest products research opportunities. Summer recreation and winter ski area development and expansion make these industries major customers for Station research programs.

Non-government Organizations (NGOs). Citizens representing themselves and special interest groups in land management planning efforts are a significant group requesting research information, and special interest groups are becoming increasingly aware of, and are valuing, research information for their uses. Some of these groups include: The Wilderness Society, Northern Colorado Bark Beetle Cooperative, American Forest and Paper Association, Society of American Foresters, Malpai Borderlands Group, American Fisheries Society, the Front Range Fuels Treatment Project, and the Soil and Water Conservation Society of America.

Tribal Governments. The Station supports a number of working relationships with several Tribal governments in many parts of our territory. For instance, scientists are working with the Confederated





Salish and Kootenai Tribes of the Flathead Indian Reservation in Montana to understand the personal and community meanings attached to lands bordering the Mission Mountain Tribal Wilderness

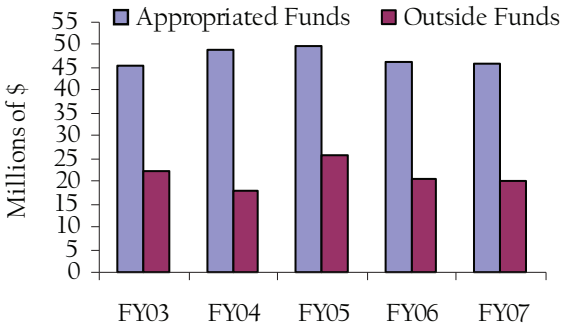
International Cooperation. Station scientists often travel to other countries to cooperate with scientists, universities, institutions, and government agencies on a variety of natural resources projects and issues. International partners also come to the United States to cooperate with our scientists.

University and Non-university Cooperators. We maintain an active cooperative research program with universities and other partners in order to share expertise and facilities to assist Forest Service research and development projects.

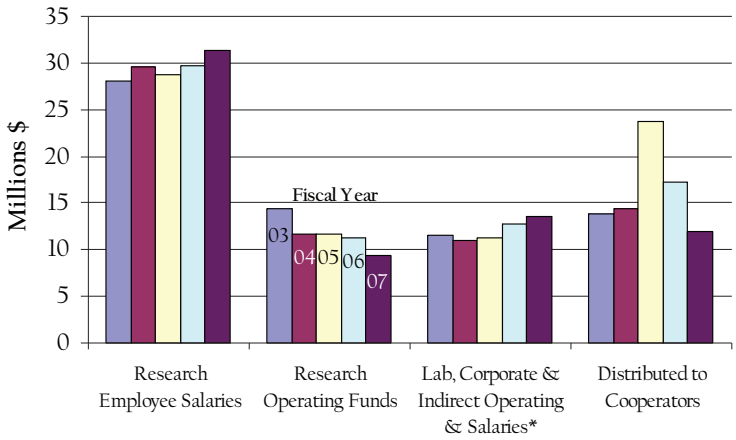
Total Incoming funding: $66.2 million
Base Research Appropriations: $38.2 million
National Fire Plan Appropriations: $7.8 million
Lab, Corporate, & Indirect Client Support: $1.7 million
Direct Client Support for Research*: $18.5 million

**Direct client support for research includes funding from: LandFire, universities, other federal and state agencies, FS regions, stations and the Washington office, and other outside sources. Outside funds calculations do not include Army.*

RMRS Incoming Funding Trends (FY03-07)

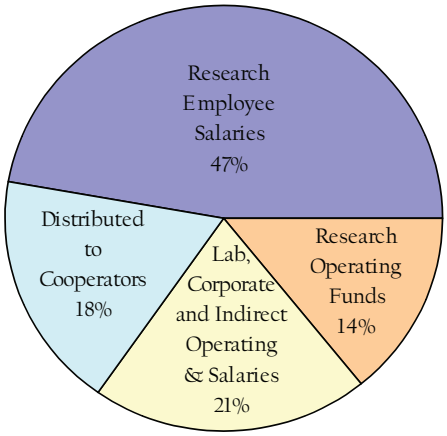


RMRS Funding Distribution Trends (FY03-07)

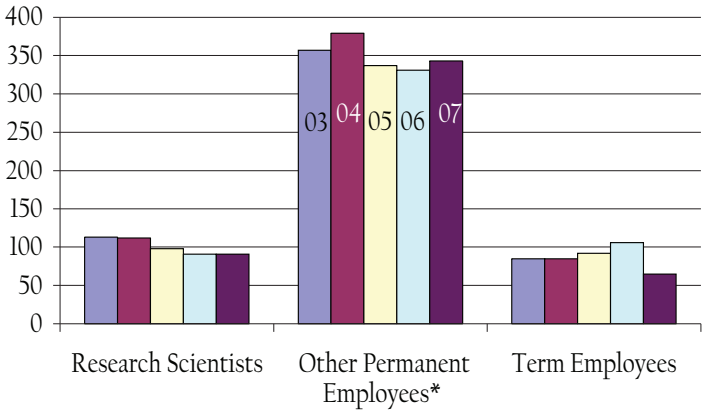


*FY04-06 included one-time facilities funding

FY07 Total Distribution of Funds
Employee Salaries and Costs: $31.4
Research Operating Funds: $9.3
Lab Support & Corporate Costs: $13.6
Distributed to Cooperators: $11.9



RMRS Workforce Trends (FY03-07)

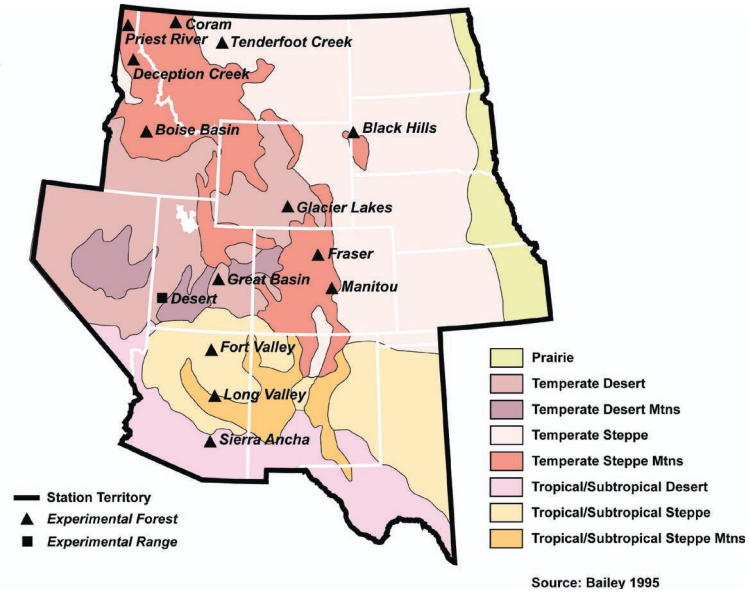


*Includes administrative, professionals, student career experience program, and post-docs

FY07 Workforce Statistics
Total Station workforce: 591 employees
Total Research Grade Evaluation Grade (RGEG) scientists: 91
Permanent (non-RGEG) workforce: 343
Term workforce: 65
Temporary workforce: 92

Long-term Research at Experimental Forests & Ranges

A unique and valuable part of the infrastructure within which we conduct research is a network of experimental forests, ranges, and watersheds. They are living laboratories where Forest Service scientists conduct studies and demonstrate research results for our stakeholders. Experimental sites remain as some of the few places where ecological research can be maintained over the long term—often longer than an individual scientist's career. Experimental areas are extremely varied and are located throughout the United States and Puerto Rico.



The Rocky Mountain Research Station administers and conducts research on 14 experimental forests, ranges, and watersheds (http://www.fs.fed.us/rm/main/expfor.html). The Fort Valley Experimental Forest, located near Flagstaff, Arizona, was established in 1908, and is the site of the first Forest Service research investigations in the Nation. Today, the Station oversees the following:

Black Hills Experimental Forest (South Dakota)—silviculture of ponderosa pine, mountain pine beetle, and wildlife habitat.

Boise Basin Experimental Forest (Idaho)—old-growth restoration, prescribed fire, and root-system structures. A current study is evaluating how forest treatments will modify both wildfire intensity and burn severity in dry ponderosa pine forests.

Coram Experimental Forest (Montana)—forest regeneration, wildlife, climate and hydrology.

Deception Creek Experimental Forest (Idaho)—sedimentation, forest genetics, root disease, small tree utilization, and fire effects. Investigations are underway on the effect of commercial thinning of mixed conifer forests on pollen from white pine infected with blister rust. Research results should shed light on the potential improvement in the genetic quality of native pollen by the harvest of trees susceptible to blister rust.

Desert Experimental Range (Utah)—cold desert plant communities, desertification, sheep management, rodent ecology, pronghorn antelope, soils, and bird and mammal populations. Recent studies are helping understand how the invasive plant halogeton displaces shrubland communities, and how best to restore halogeton-dominated sites to shrubland communities.

The Glacier Lakes Ecosystem experiments site in southern Wyoming.

Fort Valley Experimental Forest (Arizona)—forest pathology, forest restoration, wildland-urban interface studies, and fire effects.

Fraser Experimental Forest (Colorado)—nutrient cycling, snow hydrology, ecosystem carbon storage, climate, streamflow, and water chemistry. Station scientists recently initiated multiple studies aimed at addressing how bark beetle outbreaks alter subalpine vegetation and hydrology. Taking advantage of Fraser's long-term data records, these new studies will generate information about potential snow accumulation, streamflow and water quality, forest use and carbon storage, soil productivity, riparian and wetland species composition, and wood and stream channel dynamics.

Glacier Lakes Ecosystem Experiments Site (Wyoming)—seedling germination, nitrogen deposition, riparian hydrology, disturbance dynamics, tree growth, atmospheric pollutants.

Great Basin Experimental Range (Utah)—plant adaptation and succession, nutrient cycling, revegetation, restoration ecology, and game habitat. Great Basin was one of thirteen sites in the states of Utah and Nevada in which watershed-scale reconstructions of historic fire regimes were completed. Information will help understand the relationships among climate, fire regimes, and forest structure.

Long Valley Experimental Forest (Arizona)—ponderosa pine, burning interval effects, tree growth history.

Manitou Experimental Forest (Colorado)—ponderosa pine ecosystems, fire, insect and bird biology, dwarf mistletoe, and wildland-urban interface issues. Manitou is home to a new National Center for Atmospheric Research study to monitor ozone, sulfur dioxide, and aerosols. Findings will shed light on the interactions between the atmosphere and the biosphere.

The Manitou Experimental Forest headquarters building was constructed by the Works Progress Administration in the 1930's.

Priest River Experimental Forest (Idaho)—woody debris, soil productivity, acid deposition, seedling development, water yield and quality, and wood decomposition. A current study is evaluating how forest treatments will modify both wildfire intensity and burn severity in dry ponderosa pine forests.

Sierra Ancha Experimental Forest (Arizona)—long-term hydrologic studies.

Tenderfoot Creek Experimental Forest (Montana)—hydrology, climate, and regenerating and restoring lodgepole pine.

Checking snowpack on the Tenderfoot Creek Experimental Forest.

Conservation Education

Station employees regularly leave their laboratories and offices to take science to people in the community. They give presentations to landowners, school, church, and civic groups; lead field trips for the public; help with education programs in the classroom; and contribute their expertise in museums, visitor centers, and other public forums. Employees also volunteer their time to work a variety of Station-sponsored events that help underrepresented segments of society. For example:

Station scientists volunteer their time to instruct students at the Hispanic Natural Resources Career Camp.

Each year, the Station proudly sponsors the **Flagstaff Festival of Science**, held in Flagstaff, Arizona - an event that gives families a chance to see what the science organizations in the community are working on.

The Station is a primary sponsor and organizer of the **Annual Tu B'Shevat Festival** in Scottsdale, Arizona. Tu B'Shevat is the "Birthday of the Trees" in Israel. The event reflects cooperation between the Forest Service and the Jewish National Fund, which is responsible for forestry and land development in Israel.

The Station annually hosts, co-hosts or participates in a variety of camps, conferences and other events aimed at introducing students and minority youth to Forest Service programs. These include: the **Hispanic Natural Resources Career Camp**, held annually to introduce high school students to natural resource subjects such as hydrology, forestry, wildlife, entomology, climate, and forest surveying; the **American Indian Math and Science (AIMS) Camp**, hosted annually in Polson, Montana, by the Station, the Salish-Kootenai College, and the Flathead Reservation to allow fifth and sixth graders from Tribal schools to participate in a variety of events, including natural resource management activities, career opportunities, education requirements for natural resource disciplines, leadership, communications, problem-solving skills, tribal cultures, and environmental awareness; and the **Nature High Summer Camp**, held at

the Great Basin Experimental Education Center in Ephraim, Utah. It introduces high school students from the State to natural resources, careers in resource management, the real life work of professionals, and the latest techniques and technology being used by today's resource specialists.

AIMS camp students participate in a wildfire demonstration.

The Station co-sponsors the Minority Youth Environmental Training Institute, held near Santa Fe, New Mexico. This is an intensive, hands-on, science-based educational 10-day national program designed to inspire, engage, and train Latino and minority teens on environmental and natural resource issues, and to give them information about college degrees and careers in these fields.

Station researchers in Albuquerque, New Mexico volunteer their time to provide classroom and field instruction to youngsters from Joy Junction, Albuquerque's largest homeless shelter. The Albuquerque lab has a large experimental thinning research site near Joy Junction, providing scientists with a great opportunity to engage urban youth in nature-based learning.

In Boise, Idaho, Station scientists are involved in Salmon Days, an annual event that teaches kids about the Idaho Salmon and what they go through to survive the trip from the ocean to their freshwater homes. They also participate in the "Kids in the Woods" program that introduces students, teachers and parents to the critters that are found in the local river.

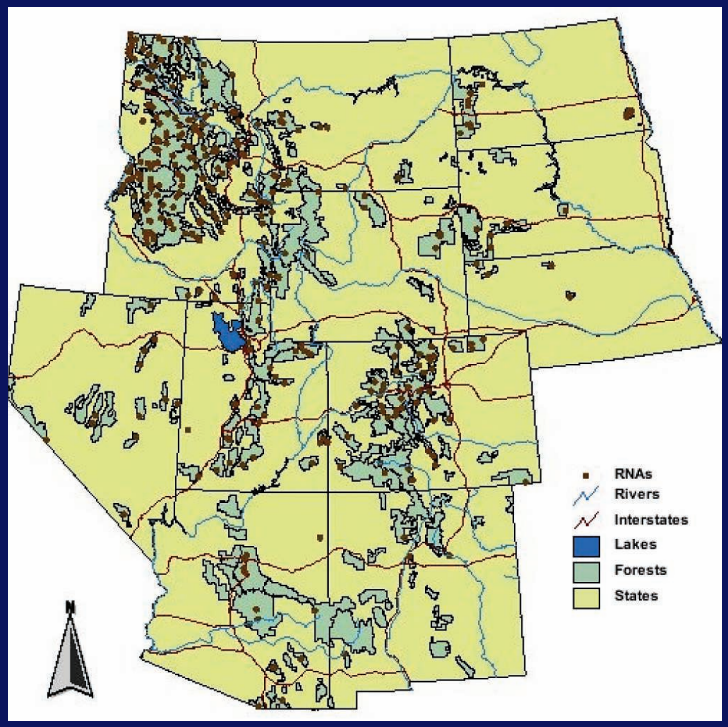
"The Hispanic Science Camp was a wonderful event – very stimulating and educational. I hope a precursor of many more such events to come. The sessions conducted by your scientists were enlightening and captured the imagination; the interviews, revealing and fun." (Education Editor, *Latino SUAVE* ***magazine)***

Research Natural Areas: Conserving Biological Diversity

The Rocky Mountain Research Station oversees activities on more than 200 Research Natural Areas (RNA). This network of natural ecosystems has been set aside for the purposes of scientific study and education, and for maintenance of biological diversity.

These areas represent a wide variety of habitats and ecosystems from alpine ecosystems to lowlands; and from coniferous forests of the Northern Rockies to semiarid deserts of the Southwest and prairie ecosystems of the Great Plains.

The Forest Service Research Natural Areas System represents a valuable ecological resource for scientists, managers and educators. The Forest Service encourages scientific and educational use of Research Natural Areas. Scientists, land managers and educators who are interested are asked to submit a request to the Rocky Mountain Research Station. Additional information is available on our website at http://rna.nris.state.mt.us/.



Research Natural Areas within the Rocky Mountain Research Station territory.

Recent activities within the Station's Research Natural Areas (RNA) include:

- **Upper Shoshone Creek RNA (Idaho-Montana Border):** Much of this RNA was burned in a wildfire in 2006. In 2007, the Station developed a management plan with the Idaho Panhandle National Forests to control invasive weeds that germinated in the burned area.
- **Upper Fishhook RNA (Idaho):** Approximately 30 acres of this 320-acre RNA burned in a wildfire in 2007. Scientists coordinated with Agency fire personnel on fire control strategies that would have the least impact on the RNA values while protecting the safety of the firefighters.
- **Colorado RNAs:** The Station and the Agency's Rocky Mountain Region are entering into a Memorandum of Understanding with the Colorado State Heritage Program to provide volunteer vegetation monitoring on a large proportion of Colorado RNAs.
- **Red Butte Canyon RNA (Utah):** Under the leadership of faculty at the University of Utah, numerous studies have been and are currently being conducted at Red Butte. They include work in hydrology (monitoring of water yield) and bird and rare plant surveys.
- **RNAs in Nevada and Utah** were included in a list of sites for a proposal to develop a more complete multi-century to multi-millennial scale regional proxy record of climate variables from bristlecone pine tree rings.
- The **Desert RNA** located within the Desert Experimental Range continues to be used in studies of salt-desert ecosystem stability.
- Scientists are evaluating the status and future use of the **Elk Creek RNA (Idaho)**, a 108-acre enclosure established in 1930 by early Station scientists. The enclosure was one of nine enclosures constructed at low, mid and high elevations on the Boise River Watershed to examine secondary succession following heavy livestock grazing in the late 1800s and early 1900s.

Adapting Under a Changing Climate

The diversity of environmental conditions across the vast territory of the Rocky Mountain Research Station—with landscapes from the Mexican border to the Canadian border—serves as a laboratory for studying climate change in the Interior West. From plants to animals, fish to wolverines, insects to fire, and biodiversity to economics, scientists are studying climate as it influences the western landscape. Human adaptation to climate change impacts is increasingly viewed as a necessary complementary strategy to mitigation—reducing greenhouse gas emissions from energy use and land use changes in order to minimize the pace and extent of climate change. Station research supports the needs of land management and planning to address the challenges of adaptation and mitigation.

Great Basin climate changes in the paleological past have set the stage for, and are influencing, current watershed processes as seen in research conducted by the Station's Great Basin Ecosystem Management Research Project. Long-term vegetation-climate interactions are the focus of research at our Reno, Nevada, Forestry Sciences Laboratory. Results will help anticipate the effects on longer-term future climate change.

The potentially changing dynamics of vegetation and landscapes under climate change are being studied by Station scientists using a suite of models from the stand and landscape level, and at the regional and national levels. Scientists in Moscow, Idaho, have developed models that predict the impacts of climate on soil erosion, including an online web site of specialized tools that can be used to estimate erosion for roads, managed forests, and forests following wildfire.

In Missoula, Montana, researchers have used the landscape fire succession model

Solar panels power rain and snow collectors at the Glacier Lakes Ecosystem Experiments Site in southern Wyoming. Collected rain and snow samples are later analyzed at a national laboratory for chemical content.

LANDSUM to generate reference conditions for different climate and fire regime scenarios.

Station scientists at the Forestry Sciences Laboratory in Idaho have developed plant-climate relationship models to explore potential impacts of climate change on plant species distributions in the western United States.

At the national level, scientists in Fort Collins, Colorado, recently cooperated with scientists at the Pacific Northwest Research Station to assess the impacts of climate change on all forests in the United States, and in what ways these impacts will influence the forest products market.

We are actively involved in determining the effects of climate change on wildlife and wildlife habitat. In Missoula, Montana, our researchers have documented the relationship between historical wolverine distributions and persistent snow. Genetic analysis reinforced these understandings and showed that these patterns have been present for at least 2,000 years. Scientists have also developed methods to generate forested landscapes given climate change and then link these landscapes to wildlife habitat models.

In Boise, Idaho, scientists are assessing climate change impacts across the distribution of the federally listed bull trout. Temperature models have been developed to predict future habitat distributions relative to different climate scenarios, and model predictions suggest even modest warming could substantially alter bull trout habitat.

In Fort Collins, Colorado, scientists are analyzing the potential effects of climate change on wildlife habitat nationally to identify geographic areas that might be particularly sensitive to stress from climate change.

The influence of climate on disturbance patterns is another focus area. Scientists are documenting the climate drivers of fire in the Northern Rockies. According to their findings, climate variability has been a strong driver of regional-fire years during the past four centuries despite major land-use change. In Utah, scientists are using data from monitoring mountain pine beetle phenology and temperatures in high elevation forests to evaluate how current trends might relate to historic patterns of mountain pine beetle caused mortality in these forests, as well as predicting trends for the future. Scientists in the Inventory, Monitoring and Analysis Program are working with collaborators to develop the long-term historical record of forest disturbance and regrowth dynamics for North America.

A world-wide network of mineral soil decomposition sites currently managed by scientists in Moscow, Idaho, will help to assess changes in carbon sequestration associated with temperature and moisture across a diversity of forest types.

Understanding the carbon cycle in forests and the role of disturbance and management is another focus of our research. Continuous observations of exchanges of carbon dioxide, water, and energy at the Glacier Lakes Ecosystems Experiment Site in Wyoming are being used to understand the carbon cycle and to probe how the annual carbon balance in this subalpine forest is affected by climatic factors, such as the local precipitation and regional climate phenomena such as El Nino and La Nina. Scientists are using ground-based measurements and advanced equipment to estimate the effects of climate, stand age and management on the carbon cycle in subalpine forests in Colorado and Wyoming.

In Fort Collins, Colorado, researchers are exploring the effects of fuels and restoration treatments on carbon storage in ecosystems, and the potential of these activities for carbon credits. Scientists and their cooperators have investigated the long-term impact that controlled burns and chipping can have on microbial response and soil carbon at the Manitou Experimental Forest in Colorado. They are quantifying the loss of ecosystem carbon directly or indirectly caused by fire, and how changing climate will interact with changing fire frequency to alter carbon storage on the landscape. Working with collaborators, scientists have developed a carbon accounting module for the Forest Vegetation Simulator (FVS) that can be used to compare carbon sequestration in alternative silvicultural systems.

At our Missoula, Montana Fire Lab, we are conducting research to quantify emissions of greenhouse gases and atmospheric pollutants from prescribed fires and wildfires, and from utilizing forest treatment residues for energy.

Our researchers and partners are working to better understand the forces that protect and threaten human relationships with wilderness. Forest Service scientists throughout the West are making a contribution to the federal Climate Change Science Program's National Assessment by examining the sensitivity and adaptability of natural and managed ecosystems to climate change, and identifying management options for climate-sensitive ecosystems. We also organized and led a number of workshops with resource managers across the United States, exploring the current information on climate change, climate change impacts to terrestrial and aquatic ecosystems, and the possible management options for adapting to and mitigating climate change. Visit the Station's web site at www.fs.fed.us/rmrs for video presentations by several RMRS scientists, and additional information on climate change research.

Station Scientists Share in Nobel Peace Prize for Climate Change Work

Station scientists Linda Joyce, Mike Ryan, Bob Musselman, and Wei Min Hao were four of thirteen Forest Service researchers selected in 2007 to share in the Nobel Peace Prize as members of the Intergovernmental Panel on Climate Change (IPCC). The IPCC is a world-wide organization of scientists that have voluntarily worked with policy makers to address climate change using the best available science. Their documents are considered to be the most credible information on climate change in the world.

Linda Joyce

Joyce, a Supervisory Research Rangeland Scientist, was an invited participant to the IPCC in 1989. In 1990, she assisted in the assessment, coordination, and consolidation of comments from the United States' review of the Forestry and Agriculture chapter of Working Group II's draft report, part of the IPCC First Assessment Report. In 1993, Joyce represented the USDA at the Ninth Plenary Session of the IPCC. She also served as a technical expert to the official U.S. delegation as they reviewed the scientific and technical issues under consideration, and was a contributor to "The Regional Impacts of Climate Change: An Assessment of Vulnerability."

Research Ecologist Mike Ryan was an invited participant to the IPCC in 1989. As a member of Working Group I, he contributed to the writing of "Effects on Ecosystems" in "Climate Change: The IPCC Scientific Assessment."

Mike Ryan

Bob Musselman

Bob Musselman, Research Plant Physiologist, was a contributing author to the 1995 assessment, "Impacts, Adaptations and Mitigation of Climate Change: Scientific-Technical Analyses."

Research Chemist Wei Min Hao was an author for the IPCC 1996 report on "Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories." His chapter focused on creating a methodology to quantify nitrous oxide, methane, and other greenhouse gases produced by fires in different ecosystems.

Wei Min Hao

Science & Wise Resource Management

Scientists and support personnel with the Rocky Mountain Research Station work to efficiently and effectively increase the understanding of Interior West ecosystems and management strategies, and provide the best service and tools possible to our customers. To help focus our strategy, formulate budgets, and enhance our collaboration with stakeholders, our research is organized under eight Science Programs: 1) Grassland, Shrubland and Desert Ecosystems; 2) Forest and Woodland Ecosystems; 3) Fire, Fuels and Smoke; 4) Air, Water and Aquatic Environments; 5) Wildlife and Terrestrial Ecosystems; 6) Inventory, Monitoring and Analysis; 7) Human Dimensions; and 8) Aldo Leopold Wilderness Research Institute.

The following pages introduce each of our Science Programs, highlight just a few of the many studies underway throughout our 14-state territory, and showcase how our science is making a difference throughout the world. For a more comprehensive look at what we do at the Rocky Mountain Research Station, please visit our website at www.fs.fed.us/rmrs.

A rainbow settles over headquarters of the Station's Desert Experimental Range in southwestern Utah. Established in 1933, it serves not only as a year-round research center, but also as a range ecology educational facility of international significance. It is one of a handful of biosphere reserves representative of cold-desert biomes worldwide and is unique in this respect in the Western Hemisphere.

Grassland, Shrubland and Desert Ecosystems

This program addresses the biology, use, management, and restoration of grasslands, shrublands, shrub steppe, and pinyon-juniper woodlands that are important for human well-being, landscape health, biodiversity, productivity, and water quality and quantity. Scientists and cooperators are solving ecological problems; identifying and developing native plants for restoration; controlling and managing invasive weeds; and improving wildlife habitats and rangelands. Learn more at www.fs.fed.us/rmrs/research/programs/grassland-shrubland-desert.

Scientists are investigating the use of a biocontrol agent to combat cheatgrass, a highly-flammable invasive annual that is rapidly spreading throughout the Great Basin and much of the West.

The Biological Control of Cheatgrass

Researchers at the Shrub Sciences Laboratory in Provo, Utah, along with cooperators, have discovered what they hope will be a new secret weapon in the war against cheatgrass, that being a native seed bank pathogen that has been found to kill up to ninety percent of cheatgrass seeds. Cheatgrass is a highly flammable invasive annual grass that is spreading throughout the Great Basin and much of the western United States following wildfire. Current work focuses on learning how to culture the fungus to produce large quantities of inoculum, as well as understanding how this pathogen impacts cheatgrass seeds and seeds of native species. Scientists hope to develop a biocontrol agent that can completely eliminate the carryover cheatgrass seeds that can be so troublesome in restoration seedings.

Find out more in Impact of the Pathogen *Pyrenophora semeniperda* on *Bromus tectorum* Seedbank Dynamics in North American Cold Deserts. *Weed Research* 47: 54-62; and A Race for Survival: Can *Bromus tectorum* Seeds Escape *Pyrenophora seminiperda* caused Mortality by Germinating Quickly? *Annals of Botany* 99: 907-914.

Expansion of Pinyon-Juniper Woodlands

Pinyon-juniper woodlands have been expanding throughout the Great Basin, leading to increases in woody fuels, fire severity and size, and the loss of some of the most diverse and productive sagebrush ecosystems in the region. A Station research paper, *Age Structure and Expansion of Pinyon-Juniper Woodlands: A Regional Perspective in the Intermountain Region*, soon to be available at http://www.fs.fed.us/rm/publications/titles/rmrs_research_papers.html, documents major increases in woodlands across the Great Basin. The report divides woodland expansion into three phases of tree dominance that illustrate the

A new Station paper documents the expansion of pinyon-juniper woodlands in the Great Basin. These photos were taken in 1973 (phase 1), 2007 (phase 2), and projected for 40 years from now (phase 3).

impacts on affected sagebrush ecosystems. The first two represent repeat photography from one site. The timing from phase one, low tree dominance to phase two, mid tree dominance, in the photos is typical for data from this study. In another 40 years the site will be in phase three.

From the sagebrush ecosystem without trees, to phase one of woodland encroachment, fuel loads double. From phase one to the phase two level of woodland dominance, the fuel loads also double. From phase two to phase three they double again. Overall, from a sagebrush ecosystem without trees to full tree dominance fuel loads increase up to eight times or more. For typical Great Basin woodlands, these changes take less than 150 years. With the woodland expansion starting in the late 1800's to early 1900's, the majority of the Great Basin woodlands are now in phase two, and rapidly approaching phase three. With less than one-quarter of the current woodlands tree dominated, this means there will be an up to a three-fold increase in tree dominated woodlands over the next 50 years. This has major implications for the size and intensity of wildfires in the region.

Resource managers throughout the Great Basin will find this publication valuable for helping to make land management decisions.

Grazing Effects on Stream Systems

Science plays an important role on the Valles Caldera National Preserve in Northern New Mexico. The Preserve was a private ranch until 2000, when Congress created it from the well-known "Baca Ranch" in New Mexico's volcanic Jemez Mountain Range. This 89,000 acre property, managed by the Forest Service, is situated inside a collapsed crater and is being used to explore new ways of managing public lands.

One study underway by scientists cooperating with the Station's Middle Rio Grande Ecosystem Management Research Unit in Albuquerque, New Mexico, focuses on the impacts of grazing on aquatic habitat, aquatic insects, and fish. Initial results from these on-going investigations show that when grazing cattle and wildlife are excluded from streamside ecosystems, overall aquatic conditions improve.

Researchers evaluate the effects of grazing on aquatic insects and fish in the Valles Caldera National Preserve.

These studies are helping enlarge the Station's native fish and habitat databases, assist in developing

ecological models for restoration of native fish communities, and assist the Forest Service and other resource agencies involved in the management of riparian (near water) areas and aquatic communities by delineating the effects of grazing on mountain streams.

Learn more about this research at http://fws-nmcfwru.nmsu.edu/fwscoop/pub/AnnualReport.pdf, and about other work sponsored by the Middle Rio Grande Ecosystem Management unit by visiting http://www.fs.fed.us/rm/albuq/.

Forest and Woodland Ecosystems

Our science helps resource managers sustain and restore the health, biodiversity, productivity, and processes in forest and woodland ecosystems which are critical sources of water, esthetic and recreation amenities, and wildlife habitat in the West. Increasingly these areas are being impacted by human developments, uncharacteristically large and severe wildfires, insect and disease outbreaks, exotic species invasions, and drought. Studies address basic vegetation and soil ecology and related processes to help understand the function, composition, and structure of these complex ecosystems. Research results help develop vegetation and fuels management and restoration strategies, tools to guide planning, and a better overall understand of the complex interactions of management actions and other disturbances. Additional information is available at http://www.fs.fed.us/rmrs/research/programs/forest-woodlands-ecosystem.

Sustaining Pine Ecosystems Threatened by White Pine Blister Rust

Restoring forests devastated by nonnative invaders often dominates the attention of forest managers. A Station scientist in Fort Collins, Colorado recently senior-authored an article in the *Journal of Forest Research* that takes a view of the invasion beyond the crisis and reveals opportunities where proactive management in threatened areas can alter the outcome of future invasion. Proactive management moves past the idea of protecting the hosts from exposure to a nonnative pathogen, and shifts the focus toward facilitating natural processes by preparing the forest so it can sustain critical ecosystem functions into the future in the inevitable presence of invaders.

Increasing the frequencies of tolerance traits within tree populations is accepted as promising for the co-existence of 5-needle pine species and white

pine blister rust (*Cronartium ribicola*). The article develops the concept that proactive silvicultural intervention can help tree populations avoid devastation by non-native pathogens. This approach is especially suitable for the high-elevation 5-needle pines that have life-history traits such as slow growth, delayed reproduction and long life spans. Accelerating generation time and providing natural selection opportunities through silvicultural treatments can reduce the ecological consequences of disease-caused mortality and sustain tree populations while maintaining broad genetic diversity.

Several national forests and parks in the Rocky Mountain region have used these results, and are working to proactively stimulate natural regeneration and identify seed trees with rust resistance in threatened stands of limber and Rocky Mountain bristlecone pine. This proactive concept is also incorporated into the Agency's range-wide whitebark pine strategy and the Rocky Mountain Region management guide for white pine blister rust. In addition, the concept has been adapted for managing Port Orford cedar stands threatened by the root disease fungus *Phytophthora lateralis* in the Pacific Southwest and Pacific Northwest Regions.

Collecting cones from a stand of limber pine that is threatened but not yet infected with pine blister rust. Seeds are being tested to help identify seed trees with heritable resistance to the rust for proactive outplanting into threatened stands. Cone collections in threatened limber pine and Rocky Mountain bristlecone pine stands are underway by several national forests and parks in the Rocky Mountain region. Rust resistance screening tests of these collections have also begun and are the first extensive screening tests for either species.

Read more about this research in Proactive Intervention to Sustain High Elevation Pine Ecosystems Threatened by White Pine Blister Rust, *Journal of Forest Research* 12 (5): 327-336 (2007).

A Soil Monitoring Protocol for the National Forests

Nationwide, the Forest Service Soil Quality Standards (guidelines developed to evaluate changes in forest soil productivity and sustainability) have not been updated or validated since their inception in the early 1980's. The Agency's Northern Region recently requested assistance from the Rocky Mountain Research Station to work on a set of soil monitoring protocols, with a common set of definitions, which could be used by trained soil scientists as well as other disciplines and the public.

Researchers at the Forestry Sciences Laboratory in Moscow, Idaho, along with cooperators, developed an assessment tool to determine the extent of soil disturbance both before and after land management activities. This tool is a huge step forward in soil monitoring on National Forests because of the use of common definitions and consistent protocols.

Researchers helped develop an assessment tool to determine the extent of soil disturbance both before and after land management activities.

These protocols are primarily designed for use on forest lands, but are also usable in rangeland ecosystems. Information collected will help describe the status and trends of soil conditions after management activities, and will provide a framework for a national set of protocols and a technical guide.

Further information can be found in: Impacts of Timber Harvesting on Soil Organic Matter, Nitrogen, Productivity and Health of Inland Northwest Forests. *Forest Science* 43: 234-251; Soil Quality Standards and Guidelines for Forest Sustainability in Northwestern North America. *Forest Ecology and Management* 138: 445-462; The Effects of Forest Management on Erosion and Soil Productivity. *Soil Quality and Soil Erosion*. Chapter 12. CRC Press. p.195-209; and *The North American Long-Term Soil Productivity Experiment: Coast-to-Coast Findings from the First Decade*. USDA Forest Service. Rocky Mountain Research Station. RMRS-P-24. p. 191-206. Find out more about soils studies at the Station at http://forest.moscowfsl.wsu.edu/smp/ltsp/index.html.

Fire, Fuels and Smoke

photo by Tom Iraci

Operating under a national charter, scientists with this program conduct fundamental research relating to wildland fire, fire behavior, the effects of fire on ecosystems and the atmosphere, and how ecosystems adapt to fire. Their mission is to improve the safety and effectiveness of fire management by creating and disseminating basic fire science knowledge, tools, and applications for scientists and managers. Find out more about this program at http://www.fs.fed.us/rmrs/research/programs/fire-fuels-smoke.

The Science Applications and Integration program administers the **LANDFIRE** (Landscape Fire and Resource Management Planning Tools) project, a five-year, multi-partner effort that produces comprehensive maps and data describing vegetation, wildland fuel, and fire regimes across the United States; and the Wildland Fire Management and Planning Research, Development and Applications project.

Evaluating the Influence of Ocean Temperatures on Wildfires

Widespread forest wildfires, such as those that swept western North America in 1996, 2000, and 2002, are driven by climate variation and can significantly affect the environment and society. In western North America, variation in climate is partly driven by variation in sea surface temperatures in the Pacific and Atlantic Oceans.

A Station scientist and cooperators used existing local wildfire chronologies reconstructed from fire scars on tree rings across the West, and existing reconstructions of sea surface temperatures developed from tree ring width and density, to examine the relationships of multi-century patterns

By removing cross sections from a stump with multiple fire scars, and assigning calendar years to the scars, researchers investigate past fire occurrence across North America.

of climate and fire. From 33,039 annually resolved fire scar dates at 238 sites, they identified synchrony in forest fires at regional and subcontinental scales. Since 1550, climate and forest fires covaried across the West, but in a manner contingent on sea surface temperatures. Researchers believe that a current warming trend in Atlantic temperatures may bring an increase in widespread, synchronous fires across the western United States in coming decades.

Details of this work are available in Proceedings of the National Academy of Sciences. 104: 543-548, and at www.pnas.org/cgi/doi/10.1073/pnas.0606078104.

Tools for Making Wildland Fire Decisions

Between 2000 and 2006 the Forest Service spent over $1 billion annually on large fire suppression. The fire management budget has become an increasingly large portion of the Agency's budget and is affecting the ability to meet other responsibilities. As a result, the Forest Service is using Approach Management Response (AMR) in its decision making on all large fires. AMR is a concept intended to maintain the Agency's commitment to safe, effective fire suppression while improving its efforts to manage costs by focusing fire fighting efforts where values at risk justify suppression expenditures, and promoting the restoration of natural fires into appropriate areas. To support AMR strategies, Agency Administrators and Incident Teams require real-time information of long-term fire spread potential and the likelihood that important resources will be affected by an ongoing incident.

Station scientists in Missoula Montana have developed RAVAR (Rapid Assessment of Values at Risk) — a new fire economics tool that provides a rapid summary of the primary resource values at risk to wildland fire. RAVAR links directly to the state-of-the-art strategic fire spread model FSPro to provide real-time strategic decision support tools. It was tested during the 2006 fire season on over 30 fires with promising results. During the 2007 season RAVAR supported over 90 fires through a web-based delivery system. The RAVAR system has been extensively used by Area Command teams assigned to Western Montana, Central Idaho, and Eastern Oregon to help prioritize

RAVAR provides a rapid summary of the primary resource values at risk to wildland fire.

large fires and distribute fire suppression resources. Within the Forest Service, the RAVAR model is a required decision support tool on all fires of national significance and a recommended tool on all fires of regional significance as required through the Chief's management efficiency efforts to manage large fire costs.

By linking the likelihood of fire reaching an identified threatened value, RAVAR allows a direct display and accounting mechanism for understanding fire risk and demonstrating the benefits from fire suppression activities through improved strategic response focusing resources where they will most likely protect the highest valued resources. Further, RAVAR promotes the concept that suppression efforts should be commensurate with values at risk.

Additional information on RAVAR is available at http://wfdss.nwcg.gov, or in *Wildfire Magazine*, March 2007, available at: http://wildfiremag.com/mag/calculated_risk/; and *Wildfire Magazine*, May 2007. Available at: http://wildfiremag.com/mag/data_pushers/.

SCI Helps Calculate Fire Suppression Costs

The Government Performance and Review Act of 1993, as well as ongoing efforts of the President's Management Agenda, require that Federal Programs develop and report outcome-based performance measures. Due to growing fire suppression costs and the lack of an adequate performance measure for suppression expenditures, Congressional appropriation language (2005) directed the Forest Service, in collaboration with the Department of Interior, to develop an interim performance measure for suppression expenditures and to begin reporting in Fiscal Year (FY) 2006.

Since 1998, Station economists had been working to develop equations that estimate fire expenditures given fire characteristics such as size, the fire environment, values at risk, and location. Given the 2005 congressional directive, these equations were further developed for use both as a performance measure and in real-time decision support, and named the "Stratified Cost Index." The Stratified Cost Index (SCI) was developed in 2006 for the Forest Service and has been adopted as a performance measure and incorporated into the Agency's Widland Fire Decision Support System (WFDSS). Development is currently underway for the Department of Interior.

SCI equations are used to calculate the expected suppression costs of large wildfires.

As a performance measure, the SCI equations are used to calculate the expected suppression cost of a large fire

(>= 300 acres). The expected cost is then compared to actual suppression expenditures, and a list of outliers (fires where actual cost is one or two standard deviations above expected cost) is provided to Forest Service Fire and Aviation Management. SCI is required on all fires estimated to cost more than $5 million. This effort will result in a common metric to normalize large fire suppression costs which can be used for reviews, evaluations, planning, and reporting.

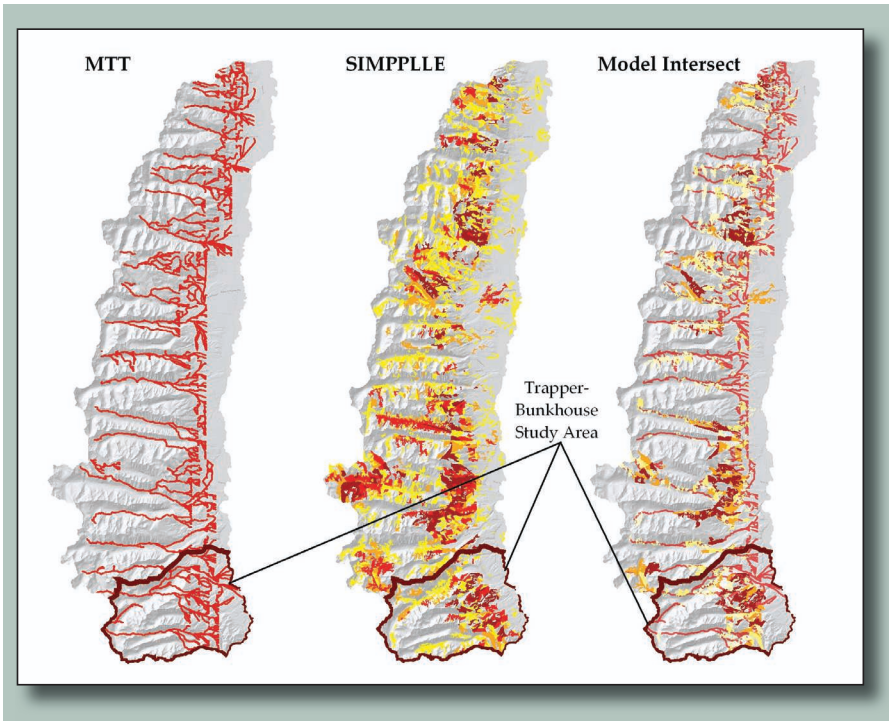
As it matures, SCI will provide information for real-time decision support to agency administrators and incident managers, along with insights into large fire suppression costs and trends, which could lead to significant cost savings.

Learn more in Estimating Suppression Expenditures for Individual Large Wildland Fires. *Western Journal of Applied Forestry* 22(3):188-196; *Wildland Fire: Management Improvements Could Enhance Federal Agencies' Efforts to Contain the Costs of Fighting Fires*. GAO-07-922T; and *Audit Report: Forest Service Large Fire Suppression Costs*. OIG Report No. 08601-44-SF. 47 p. You can also find additional information at the following websites: http://www.fs.fed.us/rmrs/news/wildfire-tools/; http://www.wildfirelessons.net/Additional.aspx?Page=96; http://www.whitehouse.gov/omb/expectmore/detail/10000448.2006.html; and http://www.wildfiremag.com/mag/data_pushers/index.html.

Integrating Fuels Treatment Objectives into Ecosystem Management

The wildfires of 2000 that burned more than 300,000 acres of the Bitterroot National Forest (MT) and adjacent lands, and destroyed numerous homes, are still fresh on the minds of people and land managers of the Bitterroot Valley. Throughout the Northern Rockies, new fires each year add to people's concerns over which piece of ground is next, and whether it will be the one next to their own homes or a favorite trout stream.

Land managers in the West face a number of issues when designing fuel reduction treatments, especially in areas with extensive wildland/urban interface. Decision making is complex because fuel treatment objectives need to be integrated with other resource management objectives and constraints. Land managers and the public would like to be able to predict what paths wildfires might follow, and how fuel reduction treatments could either alter those paths or slow down the spread of fires, thus giving firefighters a chance to protect homes and valuable natural resources.



Models helped identify candidate treatment areas and reinforced the need to focus fuel treatments in the Trapper–Bunkhouse area.

Researchers at the Fire Sciences and Forestry Sciences Laboratories in Missoula, Montana, have developed a number of models to address different aspects of scheduling fuel reduction treatments. These models focus on fuel treatments, fire behavior, and landscape analysis. However, no one model adequately addresses the variety of issues of concern to land managers and the public.

Station scientists teamed up with the Bitterroot National Forest to conduct a case study integrating these models for the Trapper Bunkhouse Land Stewardship Project. They started by modeling the Bitterroot Front, a 471,000-acre analysis area that forms the western side of the Bitterroot National Forest, most of which missed being burned in the fires of 2000. For this part of the project, they used MTT (a broad-scale model that predicts fire behavior) and SIMPPLLE (a broad-scale model of vegetation disturbance processes). By intersecting the mapped results, researchers identified three potential fuel treatment project areas along the Bitterroot Front. The area between Trapper and Bunkhouse Creeks was selected.

Scientists then used the Treatment Optimization Model (TOM) to identify specific locations where treatments might most effectively reduce fire behavior across the landscape. The results were then applied to MAGIS, a planning model that integrates vegetation information with fire hazard, economic, and other

resource information to schedule treatments over space and time. They also integrated GIS vegetation data and results from the Forest Vegetation Simulator (FVS) into MAGIS to develop scenarios that would make the best use of budgets and reduce wildfire hazards while providing other significant resource benefits. The researchers interacted with the Forest's planning team members throughout the planning process. The main focus was on fuel reduction and economic efficiency, and the model indicated specific areas where the combined benefits could increase the overall efficiency of the project. After Forest personnel visited these areas on the ground to provide verification, researchers created a "model-assisted" alternative for a draft environmental impact statement.

Finally, two action alternatives were evaluated using fire behavior modeling to provide a virtual test of how effectively the proposed treatments were likely to alter future fire behavior across the entire project area. The primary modeling tool was FlamMap, a product of the Fire Sciences Laboratory that computes potential fire behavior characteristics (spread rate, flame length, fire line intensity, etc.) over a landscape. Proposed treatments were compared to the no action alternative, and results show that the model-assisted alternative may more effectively constrain future fire behavior than treatments using conventional planning processes.

Working with the Bitterroot National Forest planning team was an important part of this project. Researchers discovered that managers were impressed by what the modeling could accomplish - providing an analytical way, rather than a subjective way, to come up with and evaluate alternatives.

Additional information can be found in BEMRP: Conducting Research, Sharing Results. *ECO-Report*. Missoula, MT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Forestry Sciences Laboratory. p.3, and Using Models to Provide a Virtual Test of Forest Treatments. *ECO-Report*. Missoula, MT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Forestry Sciences Laboratory. P.4, both available at http://www.fs.fed.us/rm/ecopartner/.

Model Websites:

- FlamMap, including MTT and TOM: http://www.firemodels.org/content/view/14/28/
- MAGIS: http://www.fs.fed.us/rm/econ/magis/
- SIMPPLLE: http://www.fs.fed.us/rm/missoula/4151/SIMPPLLE/

LANDFIRE

LANDFIRE, also known as the Landscape Fire and Resource Management Planning Tools Project, is a 5-year, multi-partner project producing maps and data describing vegetation, wildland fuel, and fire regimes across the United States. Products are designed to facilitate national- and regional-level planning and reporting of wildland fire management activities. These products may also be used during specific wildland fire incidents to maximize firefighter safety, pre-position resources, and evaluate wildland fire behavior under a variety of fire weather conditions.

For instance, LANDFIRE data were used to develop long-term assessments of fire spread on recent wildfires in southwest Utah and southern Idaho. This helped reduce firefighter exposure to hazards, hazard to values at risk, and costs of perimeter fireline construction. Incident managers on those two fires estimate a $6-8 million savings as a result of modified tactical decisions based upon better-informed fire progression and spread predictions.

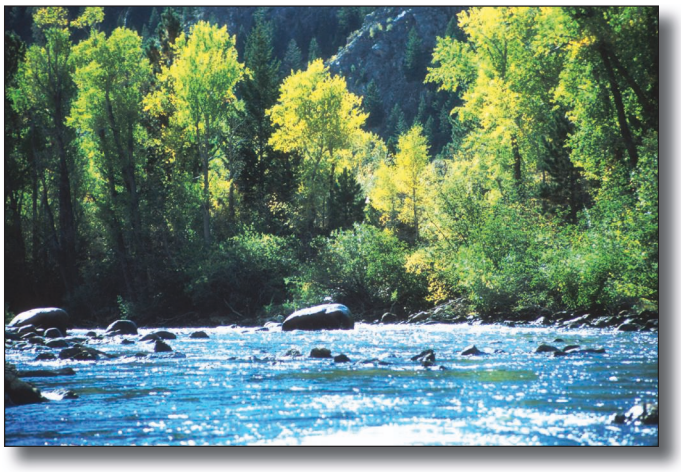
While LANDFIRE may be largely associated with fire activities, it has also been used to answer and assist with other natural resources issues. In California, LANDFIRE was used to estimate the economic value of wild pollinators (bees) to the State's agriculture. In addition, LANDFIRE vegetation data were used to help complete an analysis to an environmental impact statement regarding bighorn sheep in the Hells Canyon area of Oregon, Idaho, and Washington.

You can learn more about LANDFIRE and its many applications at www.landfire.gov.

LANDFIRE products are used to maximize firefighter safety, pre-position resources, and evaluate wildland fire behavior under a variety of fire weather conditions.

Air, Water and Aquatic Environments

Air quality, water availability, water quality, and aquatic habitats are critical issues within the rapidly changing Western United States. Program scientists develop knowledge and science applications related to air and water quality, as well as habitat quality, distribution, diversity, and persistence of fish and other aquatic species. Research results help understand natural processes, and how human management and other interventions impact these critical resources. Additional information can be found at http://www.fs.fed.us/rmrs/research/programs/air-water-aquatics.



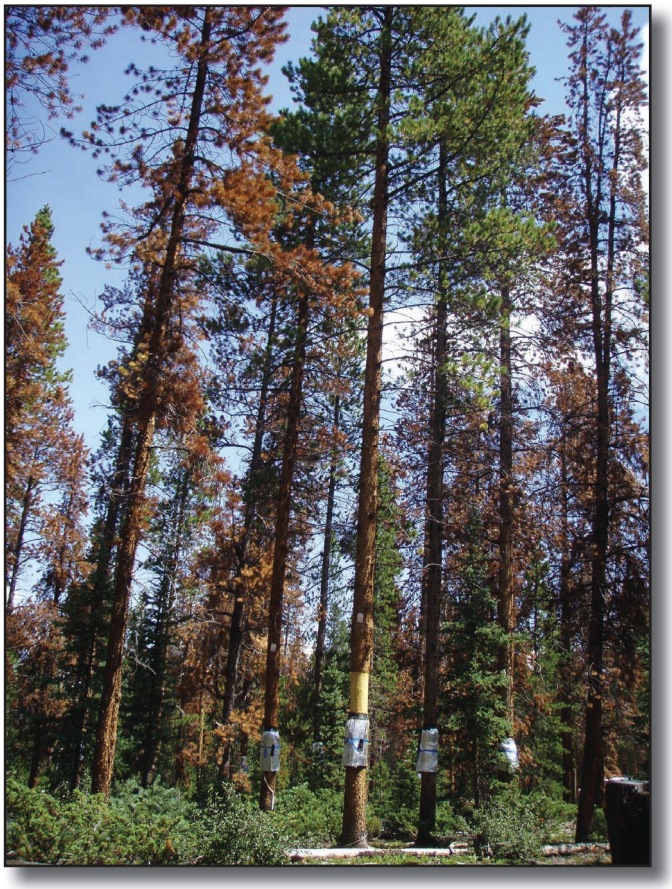
Studying the Consequences of Bark Beetle Outbreaks on Mountain Watersheds

Widespread bark beetle outbreaks and subsequent forest management activities will alter landscapes throughout the West for the next century, yet little is currently known about how this natural disturbance will affect mountain watersheds and the quantity and quality of the water they produce.

At the Station's Fraser Experimental Forest in central Colorado, researchers rely on long-term climate, streamflow, sediment, vegetation and other data records to detect physical, biological and chemical changes resulting from extensive forest canopy mortality. In addition, new studies that link tree, hillslope and other processes will generate information about snow accumulation, streamflow and water quality, forest water use and carbon storage, soil productivity, riparian and wetland species composition, and large wood, sediment and stream channel dynamics in logged and untreated areas infested by bark beetles. For instance, sensors have been added to gaging and monitoring stations to assess changes in sediment transport in conjunction with streamflow and nutrient dynamics due to beetle outbreak. Studies were established along four streams to measure the impacts of the beetle kill on stream channel characteristics and large wood loading; co-located riparian plots will help to determine the vulnerability of riparian corridors to beetle impacts. Preliminary details are available in Increased Instream Wood Loading Attributed to Mountain Pine Beetle Outbreak in Subalpine Watersheds. American Geophysical Union, Fall Meeting 2006.

Scientists at Fraser are also looking at tree mortality following bark beetle attack. When mountain pine beetles (MPB) attack a tree, they disturb two

fundamental tree growth processes. First, the beetles and their larvae feed on the food-conducting tissue in the outer bark, resulting in a certain degree of girdling. Second, the beetles introduce blue-stain fungi that grow in the water conducting tissue of the tree, reducing the ability of the tree to conduct water from the soil to the canopy. Both processes have been suggested as the cause of tree death following bark beetle attack. Station scientists have initiated an experiment to examine the relative roles of these processes on tree mortality. In 2006, they began comparing water use and tree growth in infested, mechanically girdled (no beetle) and control trees (no beetle or girdle). Initial results indicate tree water use in MPB infested trees declines rapidly within three weeks following attack and is essentially zero at the beginning of the next growing season. Although tree water use also declined following the mechanical girdling treatments, girdled trees were still actively growing and using water as of August 2007 with similar growth rates of new foliage relative to controls. Results from this experiment indicate that the introduction of blue-stain fungi is the primary mortality agent following attack, killing trees long before girdling can. This work showcases the mechanism behind a widespread forest disturbance throughout North America. Results of this study are being sent to a peer reviewed journal for publication.



Trees that received a 100 percent girdling treatment are still actively growing one year later.

In addition, Station scientists are actively collaborating with the Arapaho-Roosevelt and Routt National Forests in Colorado to evaluate harvesting practices and to assess how effective management practices are at sustaining forest production and protecting water quality and other watershed resources during extensive bark beetle outbreaks. Current studies on nutrient and sediment retention within riparian zones will help managers predict the impacts of fuel reduction projects on aquatic resources in areas infested by bark beetles. Such information will lead to land stewardship decisions that promote forest health objectives and are defensible to the public. Initial findings were presented to the Station's management partners at the US Forest Service Rocky Mountain Region's Hydrology, Fish and Soils meeting in July 2007.

Wildfire Impacts on Stream Temperature and Aquatic Species

The aftermath of a forest wildfire can have profound effects on streams. Changes in water temperature and sediment can impact aquatic species, some of which are designated as threatened, endangered, or sensitive. To help maintain water quality and aquatic habitats, managers need current information on the effects of wildfire on these resources and the consequences to ecosystems.

These photographs show the contrast between a recently burned stream and a stream several years after fire.

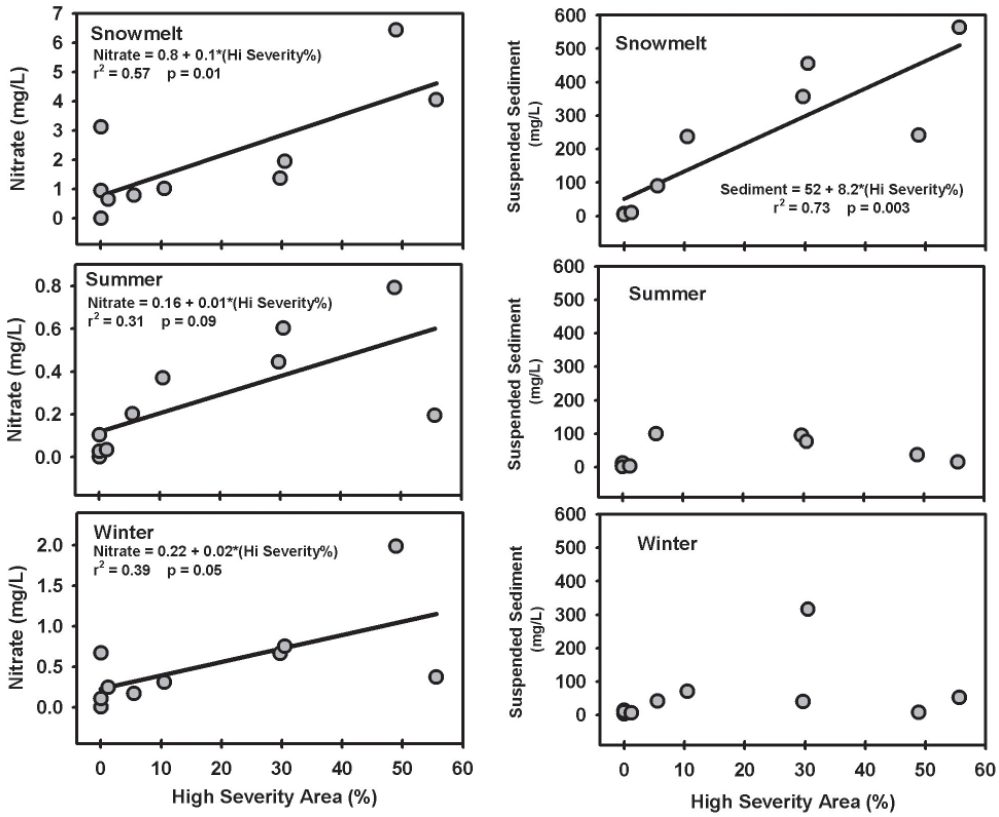
Studies conducted by scientists at the Aquatic Sciences Laboratory in Boise, Idaho, show that the effects of wildfire on stream temperatures are substantial and can last more than a decade after fire. In spite of the dramatic physical and temperature changes, researchers found that some aquatic species are resilient in terms of their distribution, such as the interior tailed frog and rainbow trout.

These and related findings are helping managers better evaluate tradeoffs between fuels management and fire suppression choices, and improve their understanding of how some species survive wildfires and other extreme events.

Additional information on these studies is available in Influences of Wildfire and Channel Reorganization on Spatial and Temporal Variation in Stream Temperature and the Distribution of Fish and Amphibians. *Ecosystems* 10: 335-346. Learn more about research at the Boise laboratory by going to www.fs.fed.us/rm/boise.

Streamwater Chemistry Response to Wildfire

The incidence of large forest fires has increased in the western U.S. during the past two decades. Wildfires such as the 2000 Hayman Fire periodically disturb Rocky Mountain montane forest watersheds, yet the influence of wildfire and fire behavior on aquatic environments remains poorly understood. Station scientists collaborated with watershed specialists on the Pike-San Isabel National Forest (CO) to evaluate change in streamwater properties at a network of monitoring sites established one year prior to the Hayman Fire. Work at these sites allows Station researchers to compare streamwater properties in burned and unburned catchments,



Seasonal relations between streamwater nitrate (left) and suspended sediment (right) and the percent of study basins affected by high-severity combustion during the Hayman Fire.

and to evaluate change in basins burned across a broad range of fire and watershed conditions.

An initial assessment evaluated changes in streamwater chemistry, temperature, and sediment immediately following the fire, and over the course of the first post-fire year. Basins located within the Hayman Fire affected by high severity fire on more than 30 percent of their area had roughly twice the streamwater nitrate and four times the suspended sediment concentrations as basins where such conditions influenced less than 10 percent of the catchment. Most streamwater ions returned to pre-fire levels within a year of the Hayman Fire, but streamwater nitrate, temperature, and suspended sediment levels remained elevated for three to five years.

These studies contribute to a greater understanding of the post-fire recovery of stream chemistry, and will help resource managers to link management actions to natural levels of variability in aquatic resources following periodic large fires.

More information is available in Initial Streamwater Chemistry Response to Wildfire in Colorado's Front Range. In: *Proceedings Second Interagency Conference on Research in the Watersheds*. Coweeta Hydrologic Laboratory, Otto, NC. pp. 89-98.

Wildlife and Terrestrial Ecosystems

This program focuses on four components: 1) sustaining species/ecosystems of concern, including multi-scale studies to identify factors that affect the persistence of species, communities, and ecosystems of concern; 2) informing federal, state, tribal, and local resource agencies on the interactions between people and fish/wildlife so they have a better understanding of public-use effects such that they can be mitigated by appropriate management actions; 3) answering questions about the amount, kind, distribution, and connectivity of habitat critical to the persistence and abundance of species; and 4) determining immediate, long-term, and cumulative effects of disturbances on species of concern and interest in the Intermountain West. Learn more at http://www.fs.fed.us/rmrs/research/programs/wildlife-terrestrial-habitats.

Birds and Burns Network

Fire size and severity have increased in dry coniferous forests throughout the Interior West over the last century - attributed primarily to fire suppression and subsequent increases in fuels. While fire managers are using prescribed burning to reduce fuels and fire risk, and restore historical fire regimes, a paucity of scientific information about the ecological consequences of prescribed burning prevents them from adequately predicting the effects of fire management on wildlife and their habitats.

Field assistants with the Birds and Burns Network prepare to place leg bands on nestling Lewis's Woodpeckers. This woodpecker species favors burned ponderosa pine forests for nesting habitat.

Station scientists, along with managers and other partners, have been studying the effects of prescribed fire on populations and habitats of birds in dry coniferous forests across seven western states over the past 5 years. They are focused on cavity-nesting birds and migratory songbirds because their long-term persistence depends on fire-prone landscapes, and several are considered species at-risk.

Studies show that bird responses to prescribed fire varies, but more often are negative for migratory birds, whereas residents had positive or neutral responses. A greater percentage of birds showed a response

to prescribed fire during the year of treatment than in the year after burning, suggesting that the influence of prescribed fire on these birds may be short term. Rather than solely destroying snags, prescribed burn treatments also recruited snags of all sizes. Researchers found that large downed wood (> 23 cm large end diameter) was significantly reduced by prescribed fire. They believe that retaining these structures for wildlife habitat may require seasonal burning adjustments.

These efforts help to understand the impacts of prescribed burning on overstory (tree) structure in terms of live and dead tree dynamics. They also identify for NEPA analysis the ecological trade-offs of prescribed burning, fire exclusion, and wildland fire for sensitive species of cavity-nesting and resident and migratory songbirds, including sensitive and indicator species. Fuel managers and silviculturists are using the data to assess the effectiveness of prescribed burns for fuel reduction and impacts on overstory and understory vegetation. Fire managers and wildlife biologists on several national forests have used Birds and Burns Network data for fire planning and assessing potential habitat changes for wildlife after prescribed fire and wildland fire.

Find out more about this work at www.rmrs.nau.edu/lab/4251/birdsnburns.

Inventory, Monitoring and Analysis

Scientists provide the data, analyses, and tools needed to identify and evaluate the current status and trends in the condition of forests and rangelands throughout the Interior West. Results help identify changes in use, management options and impacts, and threats and impacts of climate change, fire, insects, disease, and other natural processes. The Forest Inventory and Analysis Program is a central component of this Science Program. Details are available at http://www.fs.fed.us/rmrs/research/programs/inventory-monitoring-analysis.

Predicting Species Distribution

Knowing the probable location of certain key species of interest, as well as their associations to other species, are vital components of any land management activity. In 2004, a group of ecologists and statisticians met in Switzerland to discuss advances in predictive modeling of species distributions. One of the products of this workshop was a special issue of *Ecological Modelling*. The papers offer a diverse look into current modeling issues of both plant and animal species distributions at a variety of scales. Topics of these papers span several

stages of the species distribution modeling process, and are central to the proper modeling of species distribution. The papers provide a broad-based context to evaluate modeling tools and advance our ability to more accurately predict species distributions, leading to improved maps that can help land managers make more informed decisions. Station scientists and their collaborators participated in editing this special issue and contributed to some of the individual papers.

Read more in Further Advances in Predicting Species Distributions. *Ecological Modelling* 199: 129-131; Predicting Tree Species Presence in Utah: A Comparison of Stochastic Gradient Boosting, Generalized Additive Models, and Tree-based Methods. *Ecological Modelling* 199: 176-187; and Effects of Sample Survey Design on the Accuracy of Classifical Models in Ecology. *Ecological Modelling* 199: 132-141.

Station Forest Data Assists BLM

The Bureau of Land Management (BLM) recently requested information concerning the overall condition of BLM-managed forest lands in order to understand and manage for recent changes and challenges, including the effects of drought, insect damage, mortality, and wildfire fuels.

Field crews fill out data sheets in response to the BLM request.

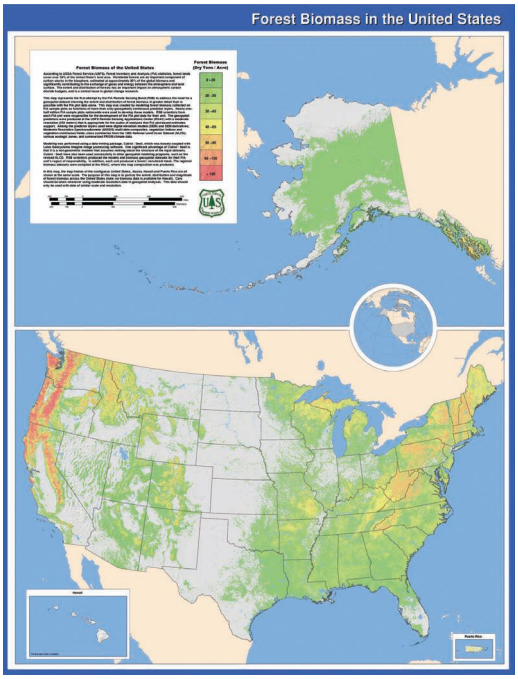
Researchers with the Inventory, Monitoring and Analysis Program in Ogden, Utah, identified specific BLM data needs that could be filled using existing information and technologies. Their data is the only source of strategic-level forest inventory information for the 33 million acres of forest land managed by BLM outside of Alaska. The 10 most common forest types on BLM lands were presented by extent, trees per acre, stand size, age, volume of biomass, basal area, stand density index, and number of snags. Maps on the distribution of each of the forest types were also produced, along with a map of forest types on BLM lands in Alaska.

The report will help guide future strategic goals of the BLM Forestry Program. It also identifies broad-scale concerns for BLM forests that can be

evaluated on a local scale by BLM state and field offices as they prepare and implement management plans.

Learn more in *A Report on the Potential Use of USDA Forest Service Inventory and Analysis Data by the Bureau of Land Management*, Technical Note 419, available at http://www.blm.gov/nstc/library/pdf/TN419.pdf. The report is available online at http://www.blm.gov/content/etc/medialib/blm/wo/Planning_and_Renewable_Resources/0.Par.12541.File.dat/BLMForestLands2006.pdf.

Forest Biomass Map Now Available



Forest inventory data collected by the Forest Service's National Forest Inventory and Analysis (FIA) Program support estimates of forest population totals over large geographic areas. Regional maps of forest characteristics make these data more accessible and useful to a larger, more diverse audience. Of particular interest are maps of forest biomass which permit estimates of forest carbon storage and net fluxes from land use change.

Station researchers with the Inventory, Monitoring and Analysis program in Ogden, Utah have teamed with other FIA units, the Remote Sensing Applications Center, and the International Institute of Tropical Forestry to produce a spatially explicit data set of aboveground live forest biomass for the conterminous U.S., Alaska, and Puerto Rico.

Synthesizing point data from tens-of-thousands of ground plots into one spatial dataset, this nationwide map allows the user to assess the distribution of forest biomass, and can easily be utilized and joined with other ecosystem and atmospheric models.

Further information will be published in the journal *Remote Sensing of Environment* in early 2008. The map and related downloads are available at http://svinetfc4.fs.fed.us/rastergateway/biomass/.

Human Dimensions

This program provides social and economic science-based innovation to human societies as they develop a sustainable relationship with their environment. Major issues confronting societies across the globe, such as global climate change, energy, fire, and water, all have important social and economic dimensions that are explored and addressed by this Program. Scientists also work to improve firefighter and public safety, reduce large fire costs, and expand the treatment of hazardous fuels for watershed restoration that is strategic, cost-effective, and socially acceptable. Additional information is at http://www.fs.fed.us/rmrs/research/programs/social-economics-decision.

Utilizing Forest Thinning Residues for Energy Production: Economics and Emissions

In the western United States, there are approximately 15.8 million acres of accessible forest land that could benefit from mechanical fuel treatments to reduce hazardous fuels and the disastrous effects of severe wildfires. Past research indicates that fuel treatments on public lands have the potential to produce significant quantities of forest residue biomass. While piling and burning this biomass is a common practice, there are opportunities to instead utilize it to produce thermal energy at relatively small scales in rural areas throughout the Western U.S. Under the Fuels for Schools Program (www.schoolsforfuels.org), small scale thermal energy production facilities are now being constructed with federal and state assistance in rural communities. This, in turn, raises some questions. Is utilizing this forest residue biomass for energy production a good idea from a green house gas and air pollution standpoint? To what extent does the diesel fuel needed to collect, chip, and haul this biomass material offset

Emissions from utilizing biomass residues for direct thermal energy were compared with onsite disposal by piling and burning and using fossil fuels to produce the equivalent amount of thermal energy.

savings in fossil fuel made possible by using this woody biomass for energy? Are there fossil fuel offsets that would qualify for carbon credits in these emerging markets? How do the costs and benefits of utilizing forest residues for energy compare with onsite disposal by open burning?

At the Forestry Sciences Laboratory in Missoula, Montana, emissions from utilizing biomass residues for direct thermal energy were compared with onsite disposal by piling and burning and using fossil fuels (natural gas or fuel oil) to produce the equivalent about of useable thermal energy. All sources of emissions and energy consumption were included in this analysis, including energy expended to collect and deliver both forest biomass and fossil fuels. Based on Environmental Protection Agency emission factors, using this biomass for thermal energy would release approximately half of the carbon dioxide compared to burning the biomass at the harvest site and using fossil fuels to provide the equivalent thermal energy. Particulate matter less than 10 microns in size decreases by even more with the biomass for energy option—75 percent, and methane, a short-lived but very harmful component of greenhouse gases, can be reduced by 90 percent. Another advantage of burning biomass for energy is the net amount of greenhouse gases that remains sequestered under ground from unused fossil fuels, rather than released into the atmosphere. Hauling cost is an important component in the economics of biomass utilization for thermal energy. A cost analysis in Montana's Bitterroot Valley indicated that if thermal energy markets existed in the southern part of the valley as well as to the north, although utilizing this biomass results in a net cost in much of the valley given current fuel costs and biomass delivered values, that cost is less than on-site disposal by burning.

Information about the cost and emission trade-offs associated with utilizing forest residues from mechanical fuel treatments helps resource managers make wise decisions and assists planners in formulating public policy.

Learn more about this study in Looking at Emissions and Economics of Biomass Use. *ECO Report*. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Forestry Sciences Laboratory. p. 9-10, available at http://www.fs.fed.us/rm/ecopartner/; and Biomass Utilization Modeling on the Bitterroot National Forest. In: *Fuels Management — How to Measure Success: Conference Proceedings*, available from the Rocky Mountain Research Station as Proceedings RMRS-P-41.

Geographic Mobility and its Pressure on Wildlands

The movement of people, goods, capital, and information is a central aspect of living in an interconnected, globalized world. One example of these global flows is the increasing prevalence of what some are calling *amenity based migrations* and *multiple dwelling* (owning and residing in more than one home). Station scientists have joined with leading international researchers to focus on the impact of increasing geographic mobility on how people interweave home, work, and recreation, and how all this affects communities and landscapes. Changing lifestyles, marked by high levels of mobility and an affinity for living in or near "the woods," are putting increasing pressure on wildands and protected landscapes throughout the world.

Studies are identifying the primary values people associate with second homes and living in desirable areas.

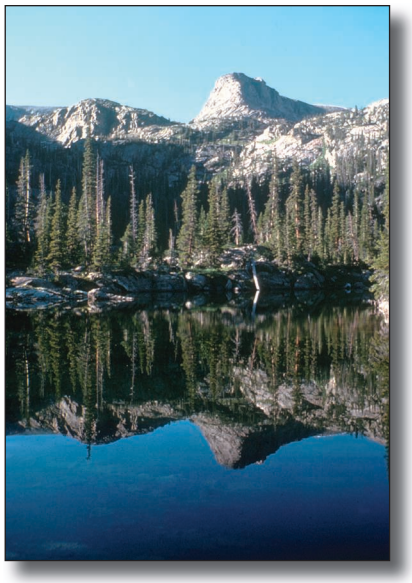
Studies have identified the primary values people associate with second homes and living in desirable areas. These include closeness to nature, refuge or oasis from the hectic modern world, and a sense of community and identity. At the same time, multiple dwellings bring additional home maintenance obligations, a more fragmented lifestyle, and added expectations and demands regarding the management of nearby public wildlands, including preferences that sometimes compete or conflict with those of full-time residents.

On a broader scale, this work points out the need to reassess basic assumptions, social practices, and institutions that are structured around the idea of a single residence. In the future, the changing nature of employment, retirement, and lifestyles are likely to influence not only amenity migration, but broader residence patterns and participation in local affairs.

Results of this work will help managers and planners address the challenges of managing the social, economic, and ecological sustainability of places as more people with more diverse ties to the landscape and community compete over the meaning and management of those places.

These issues are developed in depth in *Multiple Dwelling and Tourism: Negotiating Place, Home, and Identity*. Cambridge, MA: CABI Publishing. Additional publications on multiple dwelling and amenity migration are available on the website http://www.fs.fed.us/rm/value/research.html.

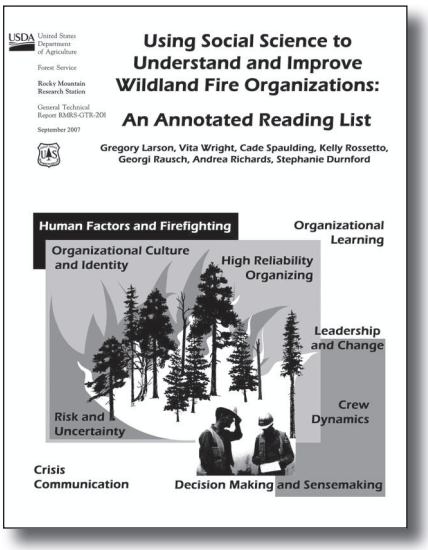
Aldo Leopold Wilderness Research Institute



Scientists and other specialists with this program work on wilderness law, policy and management to help assure that the science necessary for the understanding and stewardship of wild ecosystems is developed, delivered and applied to those responsible for managing such lands. The Institute focuses on five problem areas: 1) recreation impacts and management; 2) relationships between people and public lands; 3) wilderness fire stewardship and management; 4) wilderness in the context of large ecological and social systems; and 5) science delivery and application. Find out more at http://www.fs.fed.us/rmrs/research/programs/aldo-leopold.

Using Social Science to Understand and Improve Wildland Fire Organizations

Wildland firefighters and fire managers face a variety of mental, communication, and management challenges. To improve firefighter safety, the fire community has spent the past decade trying to understand and account for the role of human factors in wildland fire organizations. Station researchers at the Aldo Leopold Wilderness Research Institute in Missoula, Montana, are working to help firefighters and fire managers obtain additional insight into how to address some of these challenges.



They have compiled and organized knowledge from the social sciences so that it can be used to manage organizational culture and practices related to firefighter and public safety, assess the effectiveness of firefighter safety campaigns, and improve firefighter safety training. The reading list includes literature on decision making, organizational culture and identity, leadership and change, organizational learning, team and crew dynamics, and risk and uncertainty — all helpful for understanding individual behavior within an organizational setting. It

also includes readings about communicating with the public before, during, and after a crisis.

The list will benefit those in the fire community who are interested in learning more about how social science knowledge can be used to identify and solve a variety of fire management and communication problems.

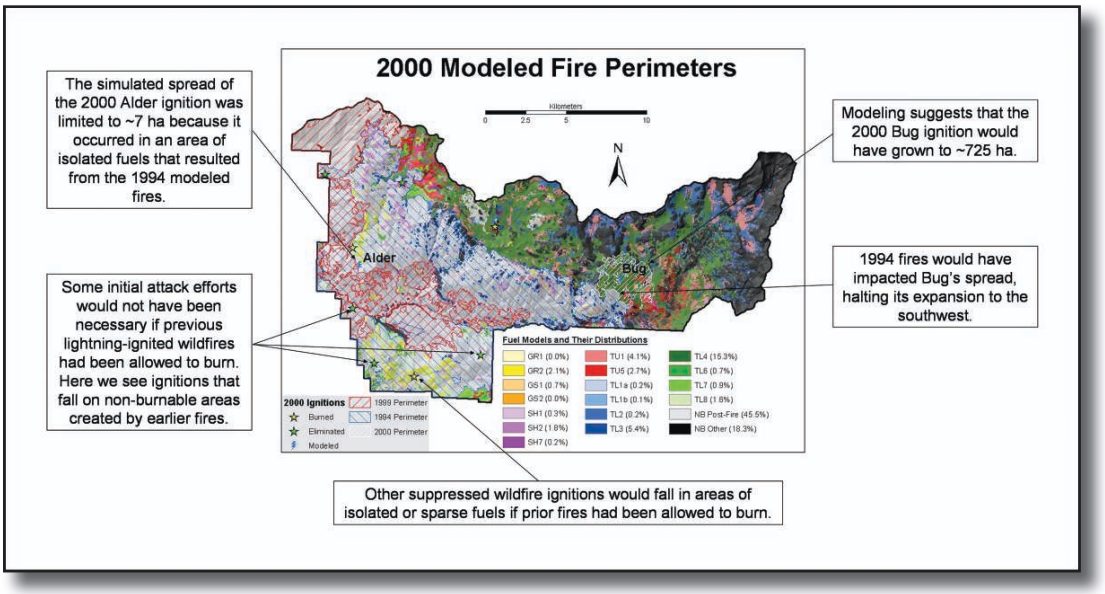
Copies of *Using Social Science to Understand and Improve Wildland Fire Organizations: An Annotated Reading List*, General Technical Report RMRS-GTR-201, are available on the Internet at www.fs.fed.us/rm/pubs/rmrs_gtr201.html.

The Cumulative Effects of Fire Suppression

Excluding fire can have untold effects on the landscape. The suppression of lightning ignited wildfires removes one of the most important natural processes from fire dependent ecosystems, and yet resource specialists currently have no way of measuring or monitoring the effects of these management actions.

Station scientists in Missoula, Montana have developed new procedures that use existing modeling tools to evaluate the cumulative effects of past fire suppression decisions in two study areas in the southern Sierra Nevada (the South Fork of the Merced River watershed in Yosemite National Park, and the Kaweah watershed in Sequoia-Kings Canyon National Parks).

Using the fire simulation model FARSITE, they sequentially simulated growth and behavior of fires to determine where they would have spread and what effects would have resulted had they not been suppressed. They found that the cumulative impacts of suppression on the Fire Return Interval Departure



Past fires have a huge impact on if, how, and where future fires burn.

(FRID) — a measure of the deviation from natural conditions - are substantial. For example, if all the ignitions simulated had been allowed to burn in the Yosemite National Park study area, they estimate that the average FRID would have improved from a value of 4.5 (high departure) to a value of 1.8 (low departure). For the area in Sequoia-Kings Canyon, the average FRID would have improved from a value of 4.3 to 0.3. Researchers also found that past fires have a huge impact on if, how, and where future fires burn. For example, if the ignitions they modeled in the Yosemite study had been allowed to burn, a total of 21 ignitions probably would not have occurred due to lack of flammable fuels. The growth of other fires would have been curtailed by burned areas. In this way, they quantified future benefits to managers from the wildland fire use strategy through its ability to reduce the number of ignitions requiring initial attack and create natural fire breaks. To measure how future fire behavior could have been moderated, they used the fire model FlamMap to compare potential fire behavior as it exists today to the potential fire behavior that would have existed had the suppressed ignitions they modeled been allowed to burn.

The methodologies and tools developed during the course of this study will allow land managers to measure the ecological and management-related benefits they are foregoing when they suppress fires. This information about the "opportunity costs" of suppression will lead to more informed decisions about whether or not to suppress future lightning ignitions and help track the cumulative effects of suppression decisions.

Additional information about this project can be found at: http://leopold.wilderness.net/research/fprojects/F006.htm under the 'Project Details' link.

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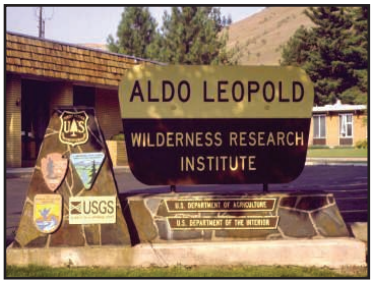

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