Research Accomplishments 2006

We develop and deliver scientific knowledge and technology that help people sustain our forests, rangelands, and grasslands.

USDA Forest Service
Rocky Mountain Research Station

ROCKY MOUNTAIN RESEARCH STATION

From the Director

The Rocky Mountain Research Station has a long and celebrated legacy of conducting relevant natural resources research throughout the Interior West and beyond. Land managers and planners regularly rely upon our science to help make wise resource decisions. Our niche among research organizations is distinct: mission-oriented, close to the customers, a reputation for objectivity and science quality, millions of acres of living laboratory, a science and support workforce that concentrates on solving complex problems, and an active presence in all the major ecosystems of the Interior West.

However, we cannot build the future resting on our laurels. The challenges related to land management and natural resources sustainability are becoming progressively more complex. Federal funding for our programs continues to decline, and there is an increasing demand for accountability and improvement in the quality, relevance and performance of science programs.

To enhance our competitiveness, streamline internal processes, and move us successfully into the 21st Century, the Station has initiated a restructuring process that centers around seven foundation science areas: 1) Grassland, Shrubland and Desert Ecosystems, 2) Forest and Woodland Ecosystems, 3) Air, Water and Aquatic Environments, 4) Terrestrial Wildlife and Habitats, 5) Human Uses, Economics and Decision Science, 6) Fire, Fuels and Smoke, and 7) Inventory, Monitoring and Analysis. We will manage this new structure to maximize integration among them toward complex, critical resource issues. Several companion Research, Development and Applications Programs will focus on tool development and science delivery, based on the needs of and joint commitment with our users. This new structure will balance the long-term and core science research that is unique to the Forest Service, with the ability to easily address current and emerging issues, all the while promoting science application and integration efforts that interface with the changing user environment.

All of our employees and many of our stakeholders have had an opportunity to participate and provide feedback on the redesign process. No lab closures and minimal personnel moves are expected to occur as the result of restructuring. We are striving to connect Station resources in virtual teams and expand the geographic scope of our investigators without costly and disruptive transfers. We will use 2007 as a transition year, with full implementation of the new structure by 2008.

This 2006 Research Accomplishments Report reflects the direction we are heading. I hope you find it useful and informative. I invite you to learn more about the Rocky Mountain Research Station by visiting our website at www.fs.fed.us/rmrs.

Dave Cleaves

Station Director

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A Look at RMRS

The Rocky Mountain Research Station is one of six 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 422 permanent full-time employees, of which 91 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, 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 & Support Services Staffs

Station scientists rely on, and work hand-in-hand with, a team of administrative and technical personnel who support the Station's research program. 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; Information Resources Management; Facilities Management; Financial Management; Human Resources; Library Services; Publishing Services; Safety, Health and Environment; Senior, Youth and Volunteer Program; and Statistics. The Station also receives administrative support from the Albuquerque Service Center.

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

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.

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.

Community Involvement & Outreach

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 serve underrepresented segments of society. For example:

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.

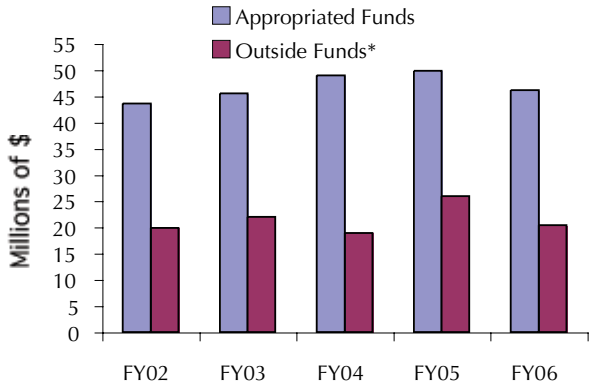
Station scientists volunteer their time to instruct students at the Hispanic Natural Resources Career Camp.

Review of Fiscal Year 2006

Total Incoming funding: $66.5 million
Base Research Appropriations: $39.6 million
National Fire Plan Appropriations: $6.6 million
Lab, Corporate, & Indirect Client Support: $5.3 million
Direct Client Support for Research:*$15 million

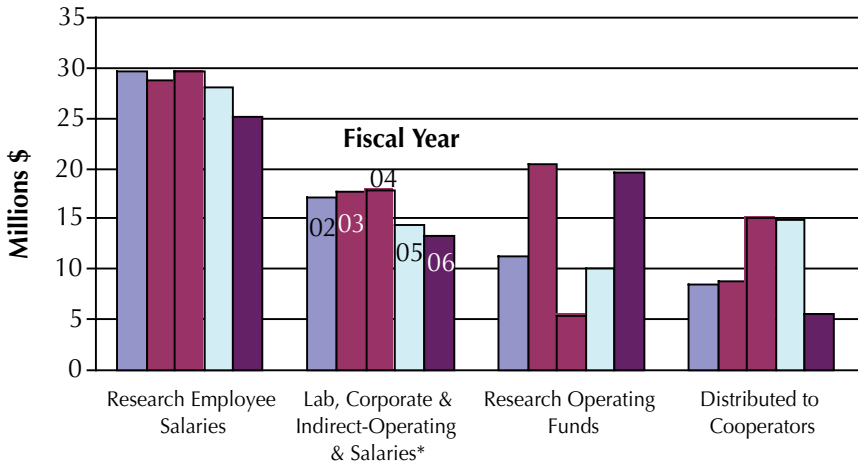
**Direct client support for research includes LandFire funding ($5.2 million); funding from FS Regions ($1.7 million), other Stations ($1.4 million), and the Washington Office ($3.2 million); university funds ($85 thousand); funding from other federal agencies ($1.8 million); and, funding from other outside sources ($772 thousand).*

RMRS Incoming Funding Trends (FY02-06)



*Does not include funding from Washington Office Detached units or the Army

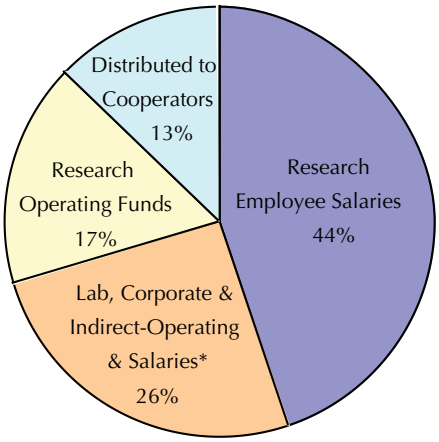
RMRS Funding Distribution Trends (FY02-06)



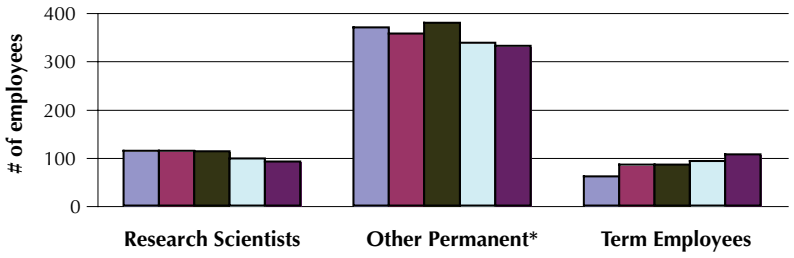
* FY04-06 Included one-time facilities funding

FY06 Total Distribution of Funds ($ millions)

- Employee Salaries and Costs: $29.7
- Research Operating Funds: $11.2
- Lab Support & Corporate Costs: $17.1
- Distributed to Cooperators: $8.5



RMRS Workforce Trends (FY02-06)



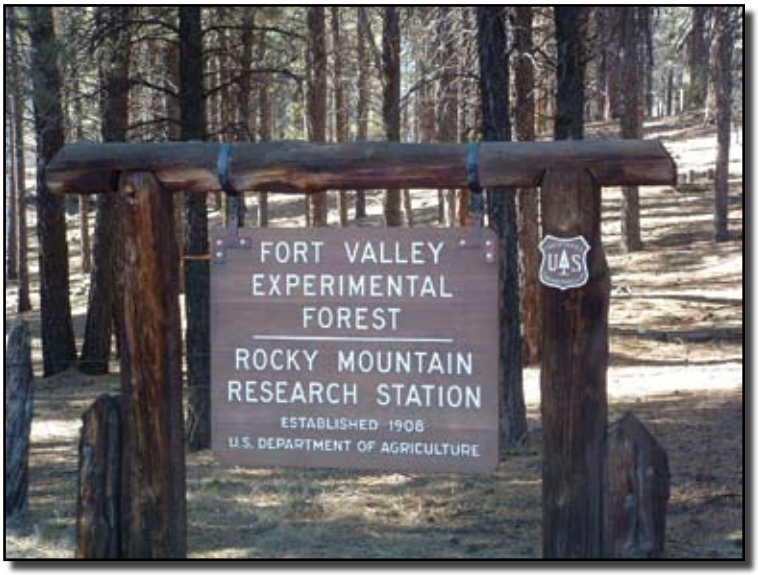
*includes administrative, professionals, student career experience program and post-docs

FY06 Workforce Statistics

- Total Station workforce: 618 employees
- Total permanent full-time paneled scientists: 91
- Permanent workforce: 422*
- Temporary and Term workforce: 196

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.



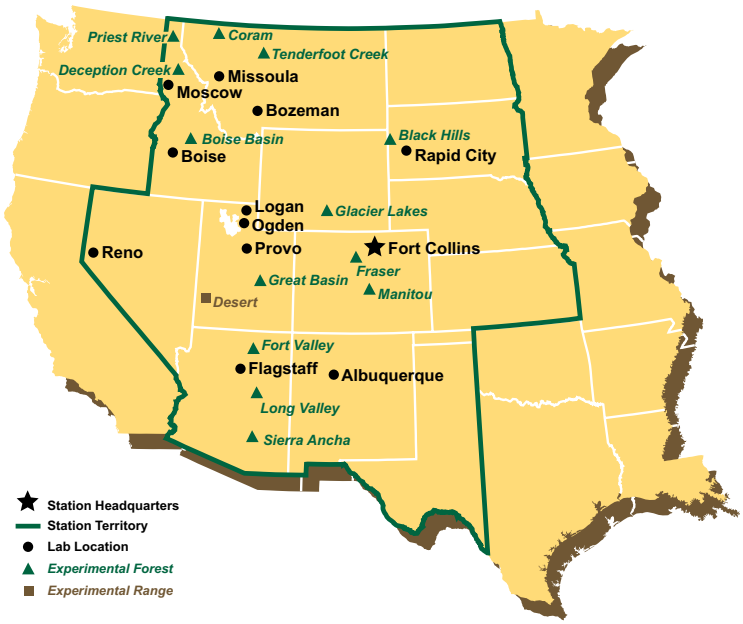
The Rocky Mountain Research Station administers and conducts research on 14 experimental forests, ranges, and watersheds (http://www.fs.fed.us/rmrs/experimental-forests). The Fort Valley Experimental Forest, located near Flagstaff, Arizona, was established in 1908, and is the site of the first Forest 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.

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.



Desert Experimental Range (Utah)—cold desert plant communities, desertification, sheep management, rodent ecology, pronghorn antelope, soils, and bird and mammal populations.

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.

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.

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.

Priest River Experimental Forest (Idaho)—woody debris, soil productivity, acid deposition, seedling development, water yield and quality, and wood decomposition.

Collecting water samples at the Tenderfoot Creek Experimental Forest in Montana.

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

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

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/.

Science & Wise Resource Management

The Rocky Mountain Research Station's mission is 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 efforts are directed toward seven focus areas: 1) Wildland Fire and Fuels; 2) Invasives; 3) Fish and Wildlife; 4) Water and Air; 5) Recreation; 6) Resource Management and Use; and 7) Inventory, Monitoring and Analysis. These areas align closely with the Forest Service's national strategic program areas.

The following pages introduce each of the focus areas, highlight just a few of the many studies currently underway throughout our 14-state territory, and showcase how our science programs are making a difference. For a more comprehensive look at research conducted during 2006, visit www.fs.fed.us/rmrs/research/highlights/. Additional information on the Station is available on our website at www.fs.fed.us/rmrs.

Experiments at the Station's Fire Sciences Laboratory in Missoula, Montana provide critical information on fire behavior.

Wildland Fire and Fuels

Fire is a major disturbance shaping ecosystems. Managing landscapes prone to wildfire is a complicated task that has become more urgent as wildfires have become more severe, especially in the western United States. The past policies of promoting fire suppression have contributed to increasingly dense forests and insect and disease epidemics. Station scientists are providing practical, science-based knowledge and tools to support public and private land managers in smoke management, fire suppression, fuel classification and monitoring, biomass utilization, postfire restoration, and predicting fire behavior and the effects of fire on forest and rangeland resources.

Research results help reduce losses to society from fire, and improve and maintain the resilience and sustainability of our Nation's natural resources.

Research results from prescribed burns in the southwestern U.S. help develop management plans for improving rangelands.

New Tools for Fire and Fuels Managers

Severe wildland fires can result in loss of life, and damage and destroy public and private resources. Scientists at the Station's Fire Sciences and Forestry Sciences Laboratories in Missoula, Montana, have developed a number of tools that provide critical information for fire specialists. One of these is FSPro, a model that simulates fire behavior (in the absence of control measures) during various potential weather scenarios and predicts the probability of fire affecting various values at risk over a period of time. Tests on a number of large fires during the 2005-2006 fire season indicate that FSPro, which uses GIS information on values at risk from the RVAR model developed by economics researchers, helps improve strategic fire suppression planning, prioritize large fires, and improve longer-term fire management and fuels planning.

Station scientists are part of a national effort to improve information for fuels planning.

Fire managers are also benefiting from research results out of our Moscow, Idaho laboratory. There, scientists are part of a national effort to improve information for fuels planning. They have developed a mixture of decision support tools, documents, and other user-friendly products that help resource specialists, National Environmental Policy Act (NEPA) planning teams, community leaders, and educators evaluate forest structure and existing fire hazards. These tools estimate the environmental consequences and costs of treating fuels, and present information on the public's understanding, beliefs, attitudes, and behaviors related to fuels management.

A series of 56 easy-to-digest one-page fact sheets, highlighting key information and findings are available at: http://forest.moscowfsl.wsu.edu/fuels/.

Station scientists are developing tools and technology to aid fire and resource managers.

Understanding Fire History Patterns Leads to Better Forest Restoration

In the last decade, wildfires have become larger and more intense, especially in the southwestern U.S.—fueled by dense forest conditions resulting from a century of fire suppression. While efforts to utilize fire to manage crowded forests and restore forest structure have begun at some locations, restoration efforts need to be conducted over larger (landscape) areas. But first, managers need to know the fire history of a particular landscape so that management plans do not stray from historical limits and patterns. Especially important is how historical fires were influenced by factors such as topography and vegetation.

Scientists at our Flagstaff, Arizona laboratory conducted studies on three distinct landscapes to determine fire history and reconstruct past fire events—something that has been lacking from most fire history studies.

Results from this research, which suggest that landscape topography influenced the size of historical fires and thus the time between fires, are being used by managers to: 1) amend forest plans to allow lightning-ignited fires to burn under certain conditions; 2) develop long-term (10-year) burn plans, and 3) assess the severity and extent of recent fires in a historical context.

By studying fire-scarred trees, Station researchers, in cooperation with the University of Arizona, are able to reconstruct the size and frequency of historical fires as far back as AD 1395.

More information on this study can be found in: "Landscape Fire History and Age Structure Pattern in the Sky Islands of Southeastern Arizona," Ph.D. Dissertation (2006), University of Arizona, Tucson AZ; and at http://www.rmrs.nau.edu/lab/4156/research.shtml.

Public Perspectives on Wildfire Risk in the Southwest

Researchers with the Station's Albuquerque, New Mexico laboratory are in the midst of a multi-year project designed to shed light on public knowledge, attitudes and concerns about wildfire and fuels management—crucial to

Studies are underway to help determine what the public's attitudes are toward wildfire and fire management practices.

successful resource management. This research is being carried out on national forests and grasslands in Arizona, New Mexico, and small portions of Texas and Oklahoma.

An edited volume, *Wildfire Risk: Human Perceptions and Management Implications*, will be published by Resources for the Future in 2007. Resource specialists utilize this cutting-edge research to:

- Examine how culture influences peoples' reaction to wildfire risk;
- Understand homeowners' attitudes about individual responsibility and its effect on human behavior;
- Determine the influence that "values" play on an individual's willingness to mitigate the risk from wildfires;
- Understand the role of communities and institutions in determining which collective actions should be undertaken;
- Model the impacts of fuels treatment programs on human activities;
- Integrate GIS mapping of human population influences into decision making models.

This body of data is being used by Forest Service and other land managers and researchers to understand and work with individuals and communities concerning both wildfire and prescribed fire risks, and to target messages and design practices that are acceptable and more readily adopted. This work has important implications for policy makers who strive to develop public policies and programs to encourage fire safe building and fuels management practices.

Additional information can be found at www.irsolutions.net/beta/ and in "The Importance of Traditional Fire Use and Management Practices for Contemporary Land Managers in the American Southwest," *Environmental Hazards* 6 (2005): 115-122.

Fuels Treatments Can Help Restore Old-Growth Forests

Old growth ponderosa pine and western larch forests were once extensive in the Inland West, but now are becoming rare. The remaining stands of old trees are at a high risk from wildfire and insects and diseases, resulting from almost a century of

Results of this fuels treatment project (before and after) show the effects of using prescribed fire and thinning to restore old-growth forests.

fire suppression and logging activities which has allowed dense ingrowth. This increased tree density creates ladder fuels (thickets of understory trees), elevating the potential for high intensity wildfire and competition for soil moisture and nutrients. Land managers recognize this condition as unsustainable, but are concerned about implementing treatments because of the potential effects on old-growth habitat.

Station scientists in Missoula, Montana evaluated treatments that help reduce the probability of high intensity crown fires in old-growth, and tested and compared the effects of these treatments on the physiology of old trees.

Research results provide clear evidence that fuel treatments in old-growth, fire-adapted ecosystems can: (1) reduce the probability of uncharacteristically severe wildfires; (2) improve the general health of old trees by reducing competition for soil moisture and nutrients, allowing for greater resistance to insects and disease; and (3) help pine and larch regenerate in the openings created by the treatments.

More detailed information on this study can be found in the Final Report to RJVA #RMRS-99563, "Physiological Responses of Old-growth Ponderosa Pine and Western Larch to Restoration Cutting and Burning Treatments", on file with the Fire Ecology and Fuels research work unit, Missoula, MT, (click on Fire Ecology/Fuels at http://www.firelab.org/).

Studies show that silvicultural treatments can help restore and maintain old-growth forests.

Working with the Public on Fire and Fuels Management Projects

Scientists with the Station's Aldo Leopold Wilderness Research Institute in Missoula, Montana, have tested a framework to guide public outreach and help facilitate and manage agency/public relations concerning fire and fuels management.

Interacting with the media is an important consideration when managing fire events.

The framework includes five guidelines that can be applied to planning and conducting public outreach: 1) recognize the potential barriers to accomplishing management objectives; 2) resist simplifying information or interpretations; 3) ensure awareness of events as they occur; 4) be prepared to respond to and recover from unexpected events; and 5) call upon appropriate expertise in decision-making and management efforts.

This framework was used to evaluate and improve upon the Lewis and Clark National Forest's (MT) public outreach efforts, and can be similarly utilized by other wildland fire and land management organizations. This effort is important because it helps managers and the public identify critical questions and the best

information for decision making, and supports the best use of public dollars and community energy.

These findings were presented to fire and fuels scientists and managers at the 1st Fire Behavior and Fuels Conference: Fuels Management—How to Measure Success, held in Portland Oregon in March, 2006, and are detailed in the article, "Organizational Characteristics that Contribute to Success in Engaging the Public to Accomplish Fuels Management at the Wilderness/non-wilderness Interface," published in the conference proceedings (http://www.fs.fed.us/rm/pubs/rmrs_p041.html). The final project report is available online at: http://leopold.wilderness.net/unpublished/UNP110.pdf.

Scientists developed a framework that facilitates working with the public on fire and fuels issues.

Invasives

Invasive (non-native) insects, diseases, plants, and animals are some of the most serious environmental and economic threats facing the Nation. Global trade and travel are causing an unprecedented movement of invasives across continents and oceans. They often have no natural enemies and can cause extensive damage to natural resources, crops, urban landscapes, and aquatic ecosystems, and can threaten biodiversity. Station researchers are evaluating the threats caused by invasives to our Nation's forests and grasslands, and developing methods to restore and rehabilitate impacted ecosystems. Research results provide managers with knowledge and tools needed to reduce or eliminate the potential for introducing invasives, and their establishment, spread, and impact throughout our Nation's forests and rangelands, both public and private.

Spotted Knapweed

Banded elm beetle

Non-native brook trout

Reducing Invasives in Cottonwood Forests of the Middle Rio Grande

The Middle Rio Grande Basin (NM) supports the most extensive remaining gallery of cottonwood forests (bosque) in the Southwest. In the past century, humans have dramatically altered vegetation in the bosque through damming, channelization, irrigation, urbanization, and other activities. As a result, many natural processes have been disrupted or altered. The absence of spring floods has prevented young cottonwoods from sprouting, allowed invasive salt cedar and Russian olive to flourish, and resulted in large accumulations of woody debris. This debris, combined with dense stands of invasive woody plants, has created an environment ripe for catastrophic wildfires.

Scientists at our Albuquerque, New Mexico laboratory initiated an interagency, collaborative project to evaluate three fuels reduction treatments in the bosque, and monitor their effects on groundwater, vegetation, soils, and wildlife. Treatments included combinations of mechanical removal of woody fuels and invasive plants, prescribed fire, and planting of native shrubs.

Land managers use findings to better understand the ecological costs and benefits of fuels and invasive plant removal in the Middle Rio Grande bosque, and how to best achieve specific goals such as suppressing exotic plants, increasing the availability of groundwater, reducing fire risk, and maintaining native flora and fauna.

More information on this study can be found in "Monitoring Bird Populations in Relation to Fuel Loads and Fuel Treatments in Riparian Woodlands with Tamarisk and Russian Olive Understories," and "Herpetological Communities of the Middle Rio Grande Bosque," in the *Monitoring Science and Technology Symposium Proceedings* (2006) RMRS-P-37-CD; and "A Soil Compaction Study on the Effects of Restoration Measures in the Middle Rio Grande Bosque," M.S. thesis (Water Resources Program, University of New Mexico).

Gathering information on plant cover and species composition in a fuels reduction treatment in a southwestern bosque.

Invasive Species in Mountain Streams

Invasive fish species threaten the survival of native fishes and aquatic ecosystems throughout the world. In the Interior West, non-native fishes represent a primary threat to threatened, endangered, or sensitive species such as bull trout, Chinook salmon, and cutthroat trout. Non-native species like brook trout are now among the most widely distributed fishes in the region.

To effectively manage invasions and their consequences, it is important to target limited resources (time and money) where chances of success are highest. To support this need, researchers at the Station's Aquatic Sciences Laboratory

in Boise, Idaho, are focused on three primary areas: detection, prediction and management.

Studies show that intentionally isolating native species to protect them from invasion can increase the chance of local extinction as they lose their connection to other habitats and populations. Direct eradication of invasive species is extremely costly and can have unwanted side effects on other native species. The risks associated with tradeoffs like these depend strongly on stream size, climate, habitat condition, species, and management goals. Research results out of the Boise lab have helped to develop integrated strategies that support consistent and defensible evaluations of these issues and helps fisheries specialists make wise use of their limited resources.

More information on this work and related issues can be found in: *Strategies for Conserving Native Salmonid Populations at Risk from Nonnative Fish Invasions: Tradeoffs in Using Barriers to Upstream Movement*, Rocky Mountain Research Station, RMRS-GTR-174, Fort Collins, CO; "Movements of Non-native Brook Trout in Relation to Stream Channel Slope." *Transactions of the American Fisheries Society*. 129:623-638; "Geography of Invasion in Mountain Streams: Consequences of Headwater Lake Fish Introductions." *Ecosystems*. 296-307; and "Changes in Distribution of Non-native Brook Trout in an Idaho Drainage Over Two Decades." *Transactions of the American Fisheries Society* 131: 561-568.

Science findings help fisheries specialists make wise use of their limited resources.

The non-native brook trout (top) is invading bull trout (bottom) habitat and threatening populations. Research is helping to understand where threats are most important and how best to manage them. (photo credit: Kentaro Morita)

Dealing with the Exotic Cheatgrass

Since American settlers arrived in the Intermountain West about 1860, major changes have occurred in semi-desert sagebrush ecosystems and pinyon-juniper woodlands. First were decreases in native grasses that were replaced by woody fuels that burn less frequently but more intensely. Second, highly-flammable, invasive annual grasses, especially the exotic cheatgrass, increased throughout Great Basin watersheds as they colonized burned areas. This combination resulted in dramatic shifts in the number of fires, their severity, and size. In many cases, the invasive species-fire cycle is converting woodland and shrubland ecosystems to landscapes dominated by non-native species, and is having highly negative effects, such as decreased biodiversity and wildlife habitat, on watersheds and riparian ecosystems. In addition, invasive species greatly hinder reclamation and restoration efforts following fire. Resource managers need the best science available to develop appropriate management prescriptions for these ecosystems.

Cheatgrass studies shed light on the spread of the invasive plant and how to help prevent initial invasion or expansion.

Station scientists in Reno, Nevada are evaluating factors that cause sagebrush ecosystems to be invaded by cheatgrass. Studies show that invasion varies across elevations, and is closely related to temperature at higher elevations and soil water at lower elevations.

Findings have helped build precision and cost-effectiveness into management techniques, including prescribed fire, aimed at preventing invasion or expansion. Scientists believe that, from a regional perspective, this preventive approach may be more effective than trying to reduce or eliminate established populations.

More information can be found in two reports accepted for publication: "Field Germination Potential of Cheatgrass in Relation to Disturbance and Elevation". *Rangeland Ecology and Management*; and "What Makes Great Basin Sagebrush Ecosystems Invasible by *Bromus tectorum*?". *Ecological Monographs*.

Improving the Fight against Forest Insects

While not a true exotic invasive, native bark beetles are a growing threat throughout the western United States. Resource managers are in need of improved tools and methods to combat infestations and maintain and restore forests.

Researchers assess bark beetle damage in a whitebark pine forest on the Boise National Forest in Idaho.

Managers routinely use funnel traps to monitor beetle populations. Researchers evaluated the effectiveness of these pheromone-baited traps to monitor bark beetle populations, the timing of flight, and beetle-caused tree mortality. They found that, in Idaho, funnel traps disproportionately sample beetle populations throughout flight season, and are not a reliable indicator of flight timing. In Utah, researchers discovered that numbers of beetles caught is highly correlated with tree mortality.

Mountain pine beetle.

At our Logan, Utah laboratory, simulation studies determined that climate warming may increase the probability that the exotic invasive gypsy moth may become established in some areas of the West, although, according to scientists, not all areas are suitable habitat. By using information on the relative susceptibility of different areas, resource managers in Utah were able to reduce the number of insect monitoring traps, saving tax dollars and increasing the accuracy in predicting populations.

Fish & Wildlife

Wildlife and fish research covers a broad array of terrestrial and aquatic species, including those that are listed as sensitive, threatened, and endangered. Today's managers are challenged with conserving critical habitats while also managing for recreation, timber, fire, insect and disease outbreaks, noxious weeds, and other resource issues. Concerns over wildlife and fish conservation have created major policy shifts in forest and rangeland management over the past 25 years. Maintaining healthy habitats, populations, and biodiversity required in laws such as the Healthy Forests Restoration Act, Endangered Species Act, and the Clean Water Act are key strategic goals for Forest Service Management.

Scientists in Missoula, Montana are studying wolverines and the impacts on their habitats from winter recreationists.

Research is underway on habitat attributes needed to maintain species across complex and dynamic landscapes. Findings help protect and enhance wildlife and their habitats, and minimize or mitigate the effects from such disturbances as fire, urbanization, roads, recreation, invasives, global climate change, and other factors. Results help define key tradeoffs and new options for blending wildlife protection with other objectives, and discover new cost-saving techniques for monitoring changes in wildlife and fish populations and their habitats.

New Genetic Sampling Technique Helps Study Sensitive Species

One of the most basic questions that often plague managers of sensitive animal species is "where do they exist on the landscape." While it is easy to answer in a broad sense, e.g., grizzly bears are found in the Rocky Mountains, to define their range on a scale that is valuable to managers requires new scientific approaches.

Station scientists in Missoula, Montana, are using non-invasive genetic sampling to determine where a particular species, or a suite of species, occurs. This type of sampling involves collecting hair, feces, or other similar samples, without ever seeing an animal, to obtain DNA and confirm species presence and sometimes determine the number of unique individuals in a forest. It also provides researchers with genetic information on the population as a whole - data which can be used to examine questions regarding abundance, and general genetic health of the population.

Researchers have developed tools that make non-invasive genetic sampling efforts possible.

Using these techniques, Station researchers and cooperators are investigating the fisher (*Martes pennanti*), a rare member of the weasel family that lives in mature forests in Montana and Idaho. Scientists have recently published tools which are making non-invasive genetic sampling efforts possible for fisher. Working with national forests, timber companies, tribes, and non-profit organizations, they have developed maps of where fishers occur that allow managers to focus on conservation efforts when this rare species is present on their forests, while allowing certain land management constraints to be removed when the animal is absent. These techniques can be employed at less expense and with less human intrusion in wilderness and other protected areas.

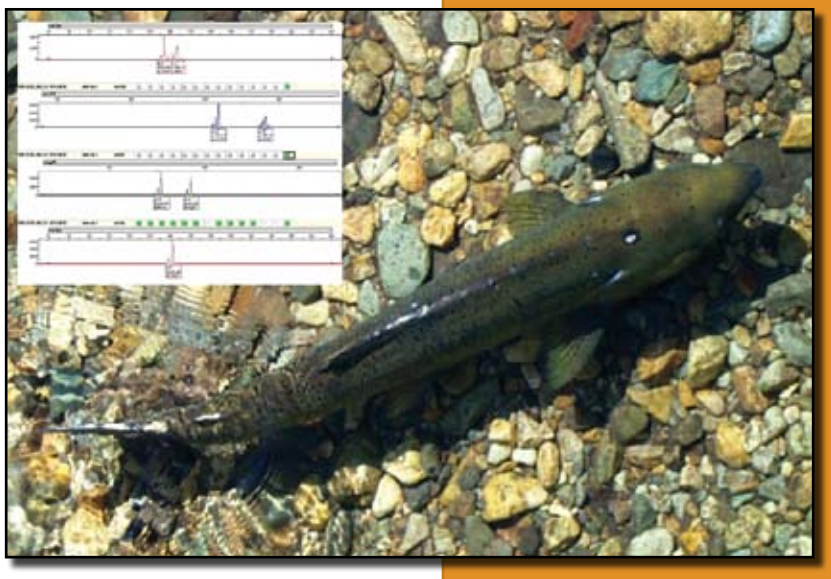
A biological technician transfers a captured fisher from its cage prior to release in Idaho.

More information on this project is available in: "When Reintroductions are Augmentations: the Genetic Legacy of Fisher (*Martes pennanti*) in Montana". J. *Mammalogy* 87: 265-271; "Testing the Efficacy of Two Methods for Snaring Hair from Mesocarnivores". *Wildlife Society Bulletin*; and "Genetic Monitoring as a Promising Tool for Conservation and Management". *Trends in Ecology and Evolution* 22.

Help for the Chinook Salmon

Most populations of Pacific salmon in western rivers have declined dramatically during the last century, and as a result, some have been listed for federal protection under the Endangered Species Act. These declines are of concern because salmon are barometers of overall environmental health, function as keystone species that support other aquatic and terrestrial organisms, are an important part of our natural and cultural heritage, and often support recreational

or commercial fisheries that create jobs and contribute to the economy. Salmon are famous for long distance migrations and their ability to return to streams where they were born. Because of this "homing" instinct, fish populations are genetically adapted to the unique characteristics of each stream. However, finely-tuned genetic adaptations can be threatened when salmon numbers are severely reduced, hatchery salmon interbreed with wild fish, or when stream environments change rapidly.



An adult Chinook salmon getting ready to spawn in an Idaho stream. Inset shows a portion of the genetic structure for a single salmon from this population.

Studies of Chinook salmon at the Station's Boise, Idaho laboratory illustrate that, despite severe population declines, wild salmon in central Idaho retain high levels of genetic variation that likely gives them the ability to adapt to changes in the environment. So, researchers believe there is still hope of maintaining these populations. Findings suggest that salmon home not just to the stream where they were born, but to specific areas within streams. It also appears that females tend to home more strongly and often show distinct preferences based on genetic differences, whereas males stray more frequently and show weaker genetic patterns.

Results of this research are helping state and federal agencies and tribes design more effective conservation and restoration strategies for threatened and endangered salmon species. Managers now have a better understanding of the importance of retaining natural populations in connected habitats. Understanding the resilience of salmon populations helps make informed decisions about the amount of stream habitat that needs to be protected and how these habitats should be arranged across a river basin. As growing human populations throughout the Pacific Northwest place increasing pressure on salmon populations, and stream environments begin to experience rapid alterations driven by climate change, these insights are key to helping sustain salmon populations.

Details of this research are available in: "Fine-scale Natal Homing and Localized Movement as Shaped by Sex and Spawning Habitat in Chinook Salmon: Insights from Spatial Autocorrelation Analysis of Individual Genotypes." *Molecular Genetics* 15:4589-4602; and "Microsatellite Variation Reveals Weak Genetic Structure and Retention of Genetic Variability in Threatened Chinook Salmon (*Oncorhynchus tshawytcha*) within a Snake River Watershed". *Conservation Genetics* DOI 10.1007/s10592-006-9155-4.

Study results help design effective conservation strategies for Chinook salmon.

Improving Habitat for Grassland Birds

Over the past 30 years, populations of many North American grassland birds have declined substantially. Scientists believe the decline may be related to human impacts such as urbanization. To conserve grassland bird communities, resource specialists need a better understanding of the key environmental factors that may contribute to population declines. Station scientists, in cooperation with Colorado State University, looked at the plight of grassland birds by studying the dry steppe landscapes of eastern Wyoming.

Their findings suggest that the distribution of grassland bird species is influenced by a complex mixture of factors that includes habitat area, landscape pattern, the availability of prey that allow grassland bird species to coexist, and the overall biodiversity in grassland ecosystems. Longer-term studies over larger areas are providing a more complete understanding of the effects of human-induced landscape change, including the loss of open space and the natural habitats they contain.

Landowners use research results to manage habitat for grassland birds.

Results provide information to grassland managers, policy makers, and community leaders in rapidly urbanizing areas on the kinds of factors that are likely to affect bird population richness. Because much of the remaining grassland habitats east of the continental divide are privately owned, results help the Agency's State and Private Forestry programs inform land owners on how to best manage natural habitat for species conservation.

More information on this study can be found in: "Factors Associated with Grassland Bird Species Richness: the Relative Roles of Grassland Area, Landscape Structure, and Prey". *Landscape Ecology* 21:569-583.

Two of the birds being studied on Wyoming grasslands are the western meadowlark and Grasshopper sparrow (photos by Dave Herr and Dan Svinger).

Water & Air

The Clean Water and Clear Air Acts, along with other legislation, require federal, state, and local land managers to protect the natural resources they oversee. These managers rely on sound science to help formulate management decisions and advise policy makers and community leaders.

Scientists supply technical tools, such as computer models and website databases, to support land managers and policy makers. They are leaders in technology transfer in fire weather intelligence and smoke forecasts for the western United States, and develop watershed simulation tools that help maintain and restore western watersheds.

Researchers monitor water quality of streams throughout the Station territory to assess the impacts of land management and other activities.

LIDAR: A New Technology to Monitor Smoke Plumes

Smoke from wildfires is a major concern for fire and air quality managers, and can severely affect visibility and air quality, resulting in disruptions in fire management operations and private business and community functions, car accidents, airport and road closures, and public health issues.

Researchers with the Station's Fire Sciences Laboratory in Missoula, Montana, are utilizing a new mobile laboratory equipped with a lidar (Light Detecting And Ranging) instrument to study smoke plumes. The scanning lidar measures the optical properties of airborne particles and smoke plume dynamics in real-time, and is the only instrument that allows its users to obtain detailed information on smoke characteristics from outside the burning area without exposure to accident and health risks.

Research results help fire and air quality managers better understand smoke particle properties, smoke movements, and how their adverse effects can be mitigated. Findings are also critical for validating smoke plume heights and dispersion for a variety of smoke prediction models. These models are useful in warning officials and citizens about smoke incidents.

The mobile lidar equipment measures the optical properties of aerosol particles in real-time over a large area.

LIDAR is the only technology capable of obtaining detailed information on smoke characteristics from outside the burning area.

More information on this study can be found in: "Determination of Extinction Coefficient Profiles from Multiangle Lidar Data using a 'Clone' of the Optical Depth". *Proceedings of the 23rd International Laser Radar Conference* (ILRC23), pp. 283-286, (2006); "Development of Lidar Techniques to Estimate Atmospheric Optical Properties". Ph. D. Dissertation of M. Adam (Johns Hopkins University, Baltimore, MD, October 2005); and "Determination of Slope in Lidar Data Using a Duplicate of the Inverted Function". *Applied Optics Early Posting Page* at http://ao.osa.org/upcoming.cfm. Additional information about this research can be found at http://www.firelab.org.

Real-Time Smoke and Weather Forecasts for Fire Managers

The Station's Rocky Mountain Center (RMC), located in Fort Collins, Colorado, provides round-the-clock comprehensive, real-time, high-resolution fire-weather intelligence and smoke forecasts for the western USA. The fire- and smoke-management community frequently looks to the RMC for highly customized, value-added weather products, and a quick response to field-users requests for weather intelligence. Its website (http://www.fs.fed.us/rmc/) offers over 100,000 weather product outputs daily and tools to assist fire and smoke managers. RMC currently supports 4 western Geographic Area Coordination Centers with critical weather information for the Rocky Mountain, Southwest, Eastern Great Basin, and Western Great Basin regions.

Products are used by fire and smoke managers to: (1) accurately assess fire danger; (2) plan prescribed burns; (3) allocate firefighting resources; and (4) measure the impacts of smoke from burns and wildfires. Increasingly, other users such as the outdoor recreation industry are using the RMC to plan activities and manage enterprises. The RMC also serves as a rich platform for exploring research questions related to the effects of climate variability, and integrating this with location-specific data and management problems.

RMC delivers real-time prediction of smoke dispersion from active fires throughout the western United States.

Cooperative Website Helps Manage Watersheds

Scientists at the Station's Southwest Forest Sciences Complex in Flagstaff, Arizona, in cooperation with the University of Arizona, maintain a website that resource specialists and others turn to for critical knowledge and data on managing watersheds in the interior western United States.

Years of accumulated watershed management research is packaged in a form that is useful to a broad public spectrum, both in the United States and around the World. Links take users to the major vegetation types in the Southwest; research data and images; a searchable bibliography that contains 900+ references to technical reports and bulletins, articles, theses and dissertations, books, and proceedings relating to watershed management research in the southwestern United States and northern Mexico; information for students and teachers; watershed management short courses; and search capabilities.

This important website provides information useful to researchers, academia, public administrators, resource specialists, elementary, middle and high school educators, and the general public. The website experiences over 333 extended use sessions per day. Learn more at http://www.ag.arizona.edu/oals/watershed/index.html.

A new website provides guidelines for managing watersheds in the West.

Recreation

The Forest Service and other natural resource agencies provide high-quality recreational experiences for the American public. The Nation's 155 national forests, 22 national grasslands, and 403 wilderness areas see well over 200 million visitors annually. A rapid increase in visitor numbers is affecting the ability to provide the benefits people want without degrading the very resources they wish to visit. Scientists are working to help managers, communities, and others better understand the risks, trends, and emerging issues affecting recreation, and new ways of meeting recreation and ecotourism needs while protecting core ecosystem features and attributes.

Science evaluates the needs and desires of recreationists and their impacts on forest and rangeland ecosystems.

Mapping the Meanings People Attach to Landscapes

Understanding how activities such as fuels management, fire suppression and fire use affect landscapes requires knowledge of not only natural elements, but social elements as well.

Following the wildfires of 2000, researchers at the Station's Aldo Leopold Wilderness Research Institute in Missoula, MT, began working with National Forest managers to understand how local communities respond to fire and fuels management decisions. A social scientist team, in cooperation with the Station's Bitterroot Ecosystem Management Research Project, initiated a pilot project to develop and test methods that identify and map "attachment to places," and integrate findings into existing fuels management tools.

Researchers conducted interviews to understand the various meanings people attach to the Bitterroot Valley landscape. They captured how people feel about physical features, and their emotional, economic and recreational attachments, even to places they have never visited. They also gathered opinions about resource management activities (such as forest thinning) and natural ecosystem processes (such as wildfire). This provided insights into the meanings people build and associate with places, how these meanings contribute to personal and community identity, and how changes in these areas may impact individuals, small social groups and the community at large. This data helps tell a collective story which provides a rich and powerful basis for conversations about change and management– what is acceptable, what's not, and why.

Results, available in both maps and narratives, are currently being used to help plan a hazardous fuels reduction project in the Bitterroot Valley, Montana. Although the data are specific to the Bitterroot National Forest, the model and methods are applicable to other areas. The Forest Service's Northern Region is also using the results to develop a program that monitors social and ecological sustainability. In addition, Station 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. Findings will provide input to fuels management strategies.

More information on this research can be found at: http://leopold.wilderness.net/.

Researchers evaluated the meanings people build and associate with "special places."

Researchers conducted interviews to understand the various aspects of peoples' "special places."

Understanding Wilderness Visitor Experiences

Wilderness use, particularly in areas close to large metropolitan areas, is increasing, along with controversy over how to manage popular wilderness trails and destination areas. Much of the controversy stems from divergent interpretations of the 1964 Wilderness Act that describes what wilderness should offer—"outstanding opportunities for solitude or a primitive and unconfined type of recreation." There is growing debate about what causes more degradation of solitude and the primitive recreational experience: growing crowds of people, or Forest Service-imposed use limits and regulations designed to protect wilderness experiences?

To help wilderness managers make more informed decisions, a major collaborative project was undertaken between the Station's Aldo Leopold Wilderness Research Institute in Missoula, Montana, the University of Idaho, and the Pacific Northwest

Region of the Forest Service. Researchers evaluated the nature of human experiences in wilderness and how experiences vary between heavily and lightly used places, as well as between day and overnight trips. Data were collected on what people experienced, their evaluations of those experiences, and their opinions about what the Forest Service should do to manage wilderness. This project was unique in recreation research for its high degree of collaboration between management and research.

Results, of particular interest to wilderness managers and planners, and stakeholders in recreation and tourism, show that visitor opinions about appropriate wilderness management are highly divergent, and providing visitors with information and venues for discussing and deliberating about management does not reduce polarization. Any assumption that providing more information will in itself reduce conflict should be questioned. Scientists believe that wilderness managers are going to have to make tough decisions about issues for which there is little consensus among the public. This research illuminates how the majority of visitors view the trade offs between solitude and choice. Visitors recognize that there is more crowding than they prefer and that solitude is harder to find and more frequently interrupted. However, most consider crowding to not be a very serious problem. They learn to cope with crowding, either though advanced planning or simply by rationalizing crowding as a necessary evil. When faced with the alternative of Forest Service imposed use limits, most visitors appear to prefer that they be allowed to adapt and adjust to conditions, and to be free to choose whether or not to visit a crowded place.

Additional information about these studies and findings can be found at http://leopold.wilderness.net/research/fprojects/F007_B.htm.

Visitor opinions about appropriate wilderness management are highly divergent. Providing visitors with information and venues for deliberating about management does not reduce polarization.

Resource Management & Use

Scientists working under this focus area provide science, management, and technology services to forest and rangeland owners, managers, policy makers, other scientists, and the public so they can manage and use natural resources and improve the standard of living and quality of life for current and future generations. Three areas are emphasized: 1) better understand the structures and processes of forest and range ecosystems; 2) develop effective and environmentally sound technologies for managing these resources; and 3) deliver the goods and services that people use and value from forests and rangelands.

Researchers study snow accumulations in thinned forests. Results help managers determine snowmelt and runoff.

Estimating Soil Erosion Risk and Mitigation Efficiency Following Wildfire

Erosion mitigation efforts are often put in place following major disturbances such as wildfires. Soil erosion rates and the effectiveness of erosion control efforts can vary greatly and are highly dependent on climate and weather. There is also a general lack of documentation and understanding of how to design effective erosion reduction treatments following wildfire.

To address this shortfall, Moscow, Idaho scientists initiated major studies to: 1) measure soil erosion rates following wildfire; and 2) develop ways to incorporate location variability into predicting soil erosion efficacy and control.

These efforts helped Station researchers and cooperators from the Agricultural Research Service develop an online program called the Erosion Risk Management Tool, or ERMiT, that predicts postfire erosion. ERMiT not only incorporates variability into predicting erosion, but also allows users to estimate the effectiveness of seeding, applying mulch, and installing logs on hillslopes.

Risk-based soil erosion modeling is on the cutting edge of erosion prediction, and has been quickly embraced by public land managers. Over 200 public and private specialists have been trained to apply the ERMiT technology in workshops sponsored by the Forest Service and the Bureau of Land Management. In 2006, the ERMiT model was run over 2,000 times, including real-time use on actual fires. In the first three weeks of August alone, users from 9 different states on at least 20 fires used ERMiT to support over 150 wildfire impact analyses.

More information is available in: "Predicting Postfire Erosion and Mitigation Effectiveness with a Web-based Probabilistic Erosion Model", accepted for publication in *CATENA*, or on the web at http://forest.moscowfsl.wsu.edu/fswepp/.

ERMiT helps estimate the effectiveness of seeding, applying much, and installing logs on hillslopes.

ERMiT is on the cutting edge of erosion prediction and has been embraced by land managers.

Evaluating Changes in Great Basin Sagebrush and Woodland Ecosystems

Pinyon-juniper woodlands and cheatgrass have been spreading throughout the Great Basin since European settlement, 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.

Station scientists are in the midst of a Joint Fire Sciences Program-funded project to help understand the causes and effects of pinyon-juniper woodland expansion and associated increases in tree densities and cheatgrass invasion on sagebrush ecosystems. Collaborative research efforts are underway throughout the Great Basin that illustrate the use of prescribed fire and mechanical treatments to control tree expansion and cheatgrass dominance. These studies evaluate the use of these restoration tools, and identify plant species and seeding methods for restoring native Great Basin sagebrush communities.

Prescribed fire is being evaluated as a tool to help restore Great Basin ecosystems.

Research results are already guiding managers to more cost-effective and sustainable practices that restore and sustain Great Basin sagebrush ecosystems and pinyon-juniper woodlands. More information on this and related research is available at http://www.sagestep.org/.

Restoring Aspen in the Western United States

The decline of aspen forests in the western U.S. has been estimated at between 50-90 percent since European settlement. These forests provide a unique flow of ecosystem services not achieved with pure conifer forests. This decline affects water quality and quantity, and reduces species biodiversity, livestock forage, wildlife habitat, recreational opportunities, wood fiber, and aesthetics. Recently, complete die-off of aspen clones has been observed throughout the West, especially in western Colorado, southern Utah, and southwest Wyoming.

Investigations into the die-back of aspen in the western United States help develop management plans that will help rejuvenate and maintain these forests.

Station scientists in Fort Collins, Colorado and Logan, Utah, are conducting studies that compliment and bolster current information on restoring aspen forests. They are addressing how natural vegetation succession can be reset to an earlier stage in aspen, and documenting the effects of grazing by both domestic and wild animals, as well as other activities that change plant composition. They are also investigating how various management treatments such as burning, harvesting, etc. affect the reproductive success of aspen and other species; determining the frequency of fire required

to sustain aspen in mixed conifer stands where fire has been suppressed; and evaluating the relationship between aspen root density and the effectiveness of regeneration treatments.

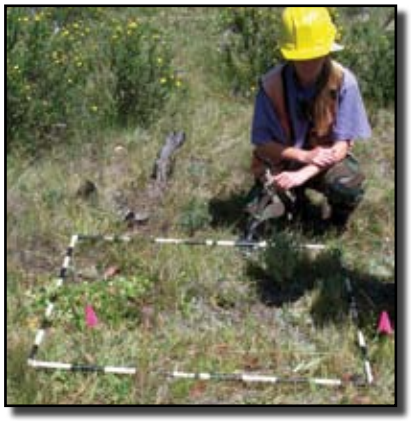
Findings will help develop management plans to rejuvenate and maintain aspen stands throughout the West, and assure their long-term presence for generations to come. Additional information can be found at http://www.fs.fed.us/rm/aspen/.

In related work, the Rocky Mountain Research Station has published a report, commissioned by the USDA Forest Service Lake Tahoe Basin Management Unit, that summarizes available information on aspen throughout North America, emphasizing ecology and management in the Sierra Nevada of California and surrounding regions. The report, *Ecology, Biodiversity, Management, and Restoration of Aspen in the Sierra Nevada*, RMRS-GTR-178, covers the historic distribution, abundance, and ecologic role of aspen, along with issues that affect aspen health and vigor, and ways to assess the condition of aspen forests and monitor the effects of management activities. In light of recent findings that aspen are declining throughout parts of the western United States, managers will find this publication of great value. Copies are available online at http://www.fs.fed.us/rm/pubs/rmrs_gtr178.html, or call 970-498-1392 for a free hardcopy.

Findings help rejuvenate and maintain aspen stands throughout the West, and assure their long-term presence for generations to come.

Inventory, Monitoring, & Analysis

The Station maintains a comprehensive inventory and monitoring program responsible for collecting, analyzing, and reporting information on America's forests and rangelands. Such information helps assess the status, trends, and sustainability of our forests, and can be used by land managers and planners and policy makers to make informed resource management decisions. For example, this "forest census" helps evaluate wildlife habitat conditions, assess current ecosystem management practices, monitor forest health, support planning and decision-making activities, and predict the effects of global change. Data is also used to project how forests and rangelands are likely to look in the future under various scenarios.



Forest and rangeland inventories help determine the effects of climate change and other impacts on resources.

Characterizing Forest Change

Over the past 50+ years, resource specialists have become more aware of forest dynamics and the role of disturbance, such as fire, in forest ecology.

The Station's Forest Inventory and Analysis (FIA) program in Ogden, Utah, is collaborating with NASA, the University of Maryland, and other Forest Service

researchers to map historical disturbances across the country. These efforts are shedding light on: 1) the historical likelihood of disturbance, which is beneficial in incorporating uncertainty in planning and managing forests; 2) the carbon flux involved with disturbance, which is central to any carbon accounting system and climate change strategies; and 3) the patterns of natural and human-caused disturbance, which is key to building ecosystem characteristics into policies and management decisions..

Resulting maps are used by managers and planners to update habitat and fuels maps, support landscape-level studies, prioritize ecosystem rehabilitation efforts, and may open up new perspectives of how disturbance operates in our forests over both time and space.

More information on these methods can be found in: "Application of Two Regression-based Methods to Estimate the Effects of Harvest on Forest Structure using Landsat Data". *Remote Sensing of Environment* 101:115-116.

Monitoring Wilderness Character

Congress, in passing the 1964 Wilderness Act and subsequent wilderness legislation, placed over 106 million acres of federal land into a wilderness system. The primary administrative mandate from these laws, and the policies of the four federal agencies who manage wilderness, is to preserve the wilderness character. However, wilderness character has never been adequately defined in terms that allow the agencies to evaluate management efforts or to assess how wilderness character is changing.

Station scientists are defining wilderness character and developing ways to monitor wilderness change over time.

To meet the challenge, scientists at the Station's Aldo Leopold Wilderness Institute in Missoula, Montana, are leading the effort to define wilderness character, and develop new and practical methods to monitor how that character is changing over time. Working with cooperators from across the Nation, this project has developed a working definition for wilderness character, identified a set of indicators and measures to be monitored, developed a cost-effective approach for gathering and reporting the data, and secured funding for development and pilot testing. The full range of managers, from wilderness field staff to regional and national program leaders to line officers, strongly supports this effort because they are getting tools to plan, manage and evaluate wilderness management. This effort is also fundamental in developing a foundation for communicating the values of wilderness preservation.

This will allow, for the first time, the means for tracking trends in wilderness character. The benefits are many, including: 1) improved accountability by linking performance measures and outcomes of wilderness stewardship directly to the

mandates of wilderness legislation and agency policy; 2) improved decision-making by knowing how specific attributes of wilderness character have changed in the past and how short-term projects are likely to affect these attributes; 3) improved the setting of priorities by knowing how different proposed actions are likely to affect wilderness character; 4) established legacy information on wilderness character that captures the institutional memory of wilderness managers so long-term and cumulative changes to wilderness character can be assessed; and 5) improved public trust and confidence in agency stewardship of wilderness.

Researchers measure the response of vegetation to treatments designed to repair high-elevation wilderness campsites.

More information can be found in: *Monitoring Selected Conditions Related to Wilderness Character: A National Framework*, RMRS GTR-151, downloadable at http://www.fs.fed.us/rm/pubs/rmrs_gtr151.html, and "Developing Indicators to Monitor the 'Outstanding Opportunities' Quality of Wilderness Character". *International Journal of Wilderness*, Volume 10, No. 3. Four additional articles in this same issue explore new social science research fields related to wilderness character and its stewardship. Additional information can also be found at http://leopold.wilderness.net/research/fprojects/F014.htm.

Advances in Resource Monitoring

Natural resource managers are continually called upon to demonstrate the effectiveness of their decisions, mitigate any undesired effects, and improve their management practices. Meeting these responsibilities requires resource monitoring and the ability to adapt to changing conditions. Monitoring requirements are established in many laws and regulations, including the Data Quality Act and the National Forest Management Act.

Scientists in Missoula, Montana, along with cooperators, have developed a rigorous monitoring program that provides valuable advances such as: 1) broad-scale, representative sampling of multiple resources using standardized protocols: 2) molecular genetics to obtain cost-effective population estimates for species of concern, and predictions of the effects of management on populations; and 3) habitat relationships models that predict the effects of management on species distributions.

This program helps specialists conduct rigorous and cost-effective monitoring of multiple resources across broad geographical areas, as well as track how resources are changing with respect to "desired conditions." It also helps determine why resource conditions change over time, and predicts future

This program helps specialists conduct rigorous and cost-effective monitoring of multiple resources.

conditions as part of an ongoing adaptive management process. Resource planners and managers now have a standardized and flexible framework to address information needs that change over time without loss of continuity, and generate data that contribute to a greater understanding of ecosystems.

For more information, refer to the following papers: "Gene-flow in Complex Landscapes: Testing Multiple Hypotheses with Causal Modeling". *American Naturalist*, Vol. 168 (2006), pages 486-499; "Research Agenda for Integrated Landscape Modeling". In review for a Station general technical report; and Effects of Habitat Loss and Fragmentation on Amphibians: A Review and Prospectus. *Biological Conservation* 128:231-240.

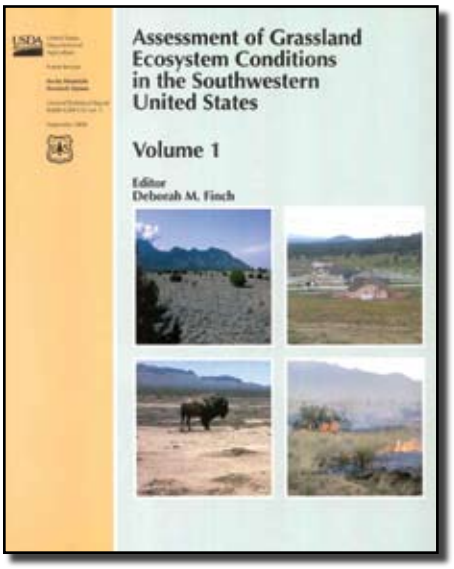
Researchers have developed a cost-effective multi-resource monitoring program to evaluate how forests change over time.

An Assessment of Grassland Ecosystems of the Southwestern United States

The Station has issued a two-volume ecological assessment of grassland ecosystems in the Southwest that will be useful to federal, state and municipal agencies, and landowners that manage grasslands in this region.

Volume I focuses on the ecology, types, conditions, and management practices of southwestern grasslands. It provides information that will help manage, develop and revise plans for grassland ecosystems and landscapes. Volume II describes wildlife and fish species, their habitat requirements, and species-specific management concerns. This assessment is regional in scale and pertains primarily to lands administered by the Southwestern Region of the USDA Forest Service (Arizona, New Mexico, west Texas, and western Oklahoma).

Copies of *Assessment of Grassland Ecosystem Conditions in the Southwestern United States*, General Technical Reports RMRS-GTR-135, Volumes I and II, can be downloaded at http://www.fs.fed.us/rm/pubs/rmrs_gtr135_1.html, and http://www.fs.fed.us/rm/pubs/rmrs_gtr_135_2.html.



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Southwestern Forest Health and Wildland-Urban Interface Fuels Management (RMRS-4156)

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Southwestern Borderlands Ecosystem Management (RMRS-4651)

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Ecology and Conservation of Terrestrial Wildlife and Habitats in the Interior West (RMRS-4251) (co-located in Fort Collins, CO)

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Watersheds and Riparian Ecosystems of Forests and Woodlands in the Semi-arid West (RMRS-4302)

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Social and Economic Values in Natural Resource Planning and Management (RMRS-4851)

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Natural Resource Assessment and Analysis (RMRS-4852)

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Ecology and Conservation of Terrestrial Wildlife and Habitats in the Interior West (RMRS-4251) (co-located in Flagstaff, AZ)

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Interior West Forest Inventory and Analysis Program (RMRS-4801) (co-located in Ogden and Logan, UT, and Missoula and Bozeman, MT)

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Sustaining Alpine and Forest Ecosystems Under Atmospheric and Terrestrial Disturbances (RMRS-4451)

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Sustaining Fish and Watershed Components of Aquatic and Riparian Ecosystems in the Central Rocky Mountains and Northern Great Plains (RMRS-4352)

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Forest Ecosystem Development and Management (RMRS-4155)

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Microbial Processes that Affect Ecosystem Function (RMRS-4552)

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Soil and Water Engineering (RMRS-4702)

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Integrated Research on Watershed Processes and Aquatic Ecology to Guide Management of Aquatic Ecosystems and Water and Soil Resources (RMRS-4353)

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Ecology and Conservation of Terrestrial Wildlife and Habitats in the Interior West (RMRS-4251) (co-located in Flagstaff, AZ)

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Shrubland Biology and Restoration (RMRS-4253) (co-located in Provo, UT)

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Ecology and Management of Wildlife and Habitats (RMRS-4201)

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Economic Aspects of Forest Management on Public Lands (RMRS-4802)

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Bitterroot Ecosystem Management Research Project (RMRS-4654)

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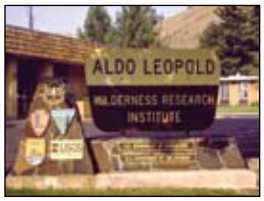

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Fire Behavior: Fundamentals and Systems Development (RMRS-4401)

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Fire Chemistry and Emission Characterization (RMRS-4404)

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Interior West Forest Inventory and Analysis Program (RMRS-4801) (co-located in Ogden and Logan, UT, Fort Collins, CO, and Bozeman, MT)

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Management for Sustainable Ecological Systems on the Northern and Central Great Plains (RMRS-4254) (co-located in Rapid City, SD)

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Ecology, Recovery, and Sustainability of Southwestern Grasslands and Associated Riparian Ecosystems and Wildlife (RMRS-4351)

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Ecology, Diversity, and Sustainability of Soil, Plant, Animal, and Human Resources of the Rio Grande Basin (RMRS-4652)

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Ecology, Paleoecology, and Restoration of Great Basin Watersheds (RMRS-4252)

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Biology, Ecology, and Management of Western Bark Beetles (RMRS-4501)

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Interior West Forest Inventory and Analysis Program (RMRS-4801) (co-located in Ogden, UT, Fort Collins, CO, and Missoula and Bozeman, MT)

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