



RESEARCH & DEVELOPMENT 2004 ANNUAL REPORT

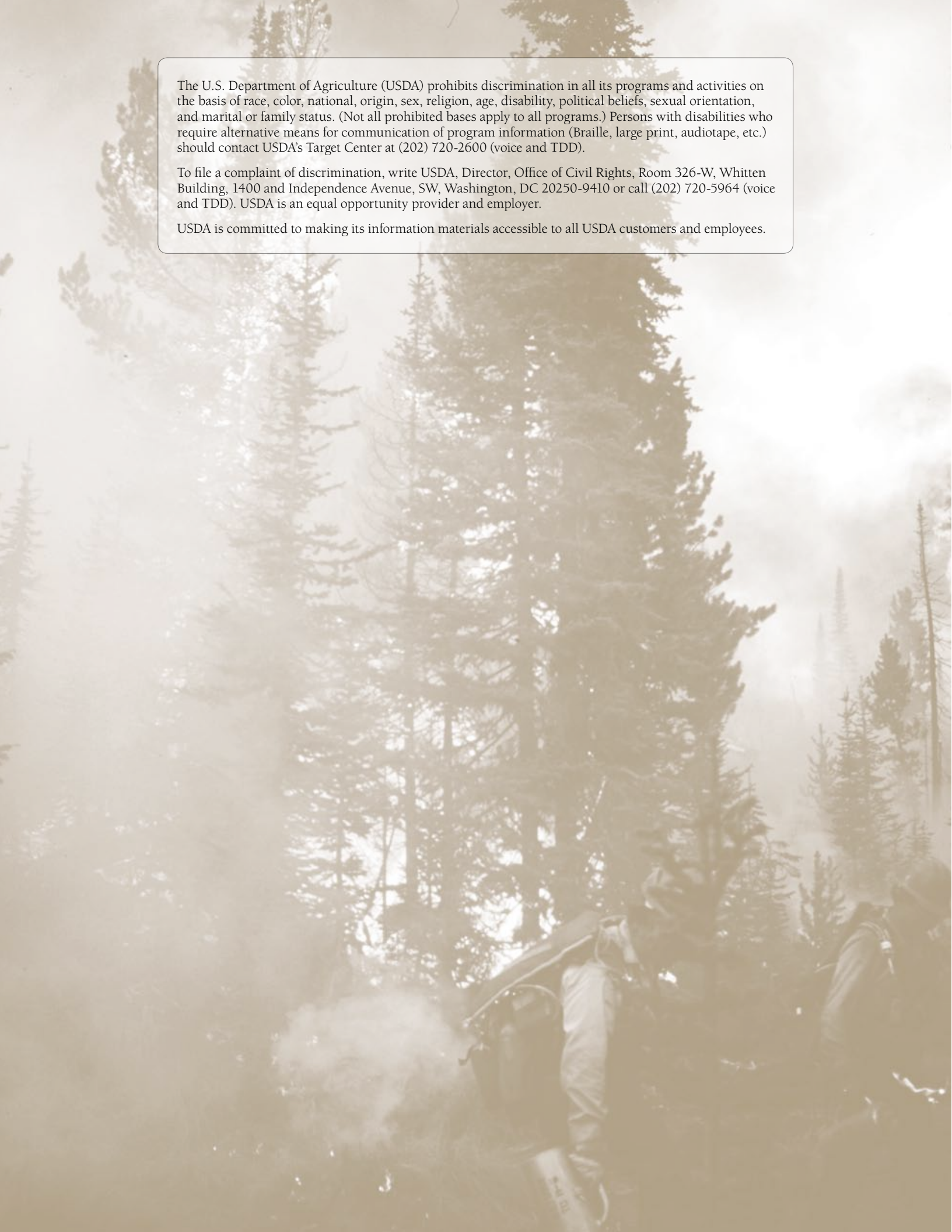
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Forest
Service

The background of the page is a sepia-toned photograph of a forest. In the foreground, the back of a person wearing a dark jacket and a hat is visible, looking towards a dense forest of tall evergreen trees. The trees are silhouetted against a lighter, hazy sky. The overall tone is warm and historical.

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LETTER FROM THE DEPUTY CHIEF



January 2005 marked my 1-year anniversary as Deputy Chief of Research and Development (R&D). The past year was as challenging and satisfying as I anticipated it would be. This report cannot capture all the work we did, but it does highlight some of our biggest accomplishments.

I recently helped mark another anniversary by attending the USDA Forest Service Centennial Congress in Washington, DC, where I shared in the pride and wonderment USDA Forest Service employees feel in being part of this enduring and evolving agency.

Research has been part of the USDA Forest Service mission since the agency's inception. I see R&D's relationship with the rest of the agency growing ever stronger in this new century as we continually seek ways to live in harmony with our dynamic environment. We can no longer afford to view the human community as something separate and apart from natural resources. The interconnections between society and the environment are profound and must be the basis for our future science endeavors.

Over the past year, I have conversed with our own scientists and others in universities, nongovernmental organizations, and industry. Several major themes that are engaging the larger scientific community have emerged as future drivers of our research and management programs:

- ▶ **Restoration and recovery—managing with change.** Large-scale disturbances, whether climate change, fire, hurricanes, or invasive species, are a fact of life. In the future, we need to better understand these changed patterns and provide the science to practitioners so they can manage disturbances more effectively. For example, how do ecosystems respond to postdisturbance actions by managers? What are the desirable future conditions for landscapes that have undergone a large-scale disturbance? How effective are alternative treatments for restoration and recovery? And how do we integrate disturbance into our near- and long-term management plans?
- ▶ **Capturing value in ecosystems.** As scientists, we need to inventory and evaluate the status and trends of ecosystem services. How can we capture value in ecosystems? How can we do a better job of describing to the American public the value of things such as water, biodiversity, and carbon sequestration? We in R&D can help develop appropriate metrics. Education and incentive programs can help sustain forest land for forest values. We have already begun such work for carbon with carbon credits.
- ▶ **Linking land use and water.** Our history of watershed research is built on understanding the links between management and hydrology, but on a local scale. Now we need to scale up the science to look at much larger landscapes. For example, how does urban development influence water quality and quantity? How do disturbance patterns influence water at different scales? And how do management, disturbance, and urbanization interact to influence ground water?

- ▶ **Understanding social dynamics and resource use.** We need to understand why people make the choices they do. What are the impacts of human migration on the spatial patterns of resource use and management? How do preferences for resource use and management vary with demographic, cultural, and other factors?
- ▶ **Providing urban natural resource leadership.** Considering the urban and suburban setting in ecological terms will help ensure a healthy environment in developed areas. It may reduce the pressure on people to move into wild lands and help prevent the continuing loss of open space. How do ecosystem changes during urbanization vary by region? How can we maintain and restore ecosystem services in rapidly urbanizing environments? How do natural resource, land use, urban growth, and other policies influence the ability to maintain ecosystem services?
- ▶ **Considering the effects of globalization.** As scientists, we recognize the enormity of this problem and know we can help use and shape global forces to influence the future. What are the impacts of global production, consumption, and competition patterns on ecosystem conditions? What are the impacts of international markets on the movement and establishment of invasive species? What are the implications of climate variability for world fiber production and ecosystem services? We definitely need to consider the impacts of international markets on the movement and establishment of invasive species.

The future is as much about **how** we do the science as what science we do. First, we must look to the past and build on the historical knowledge of our experimental forests and grasslands. We have data sets that span 80 years. What do they tell us about global change processes? We also need to capture traditional knowledge from groups that have had a close association with the land for centuries, whether they be Pacific Islanders, rural Appalachians, or our tribal colleagues. Second, we need to enhance our public-private partnerships in research and management. Universities are valuable partners for expanding our capacity to address current and future problems. Third, we must go back to the basics. We must maintain the fundamental disciplines but put them together in new ways to explore new frontiers. Fourth, and perhaps most critical, we must do a better job of linking science and practice. To do so means improving our communication of science and getting our science into a form that can be handed off to practitioners. We need to make adaptive management a reality and create an ongoing feedback loop between the science and the practice. Adaptive management embodies a simple imperative—policies are experiments, and we must learn from them.

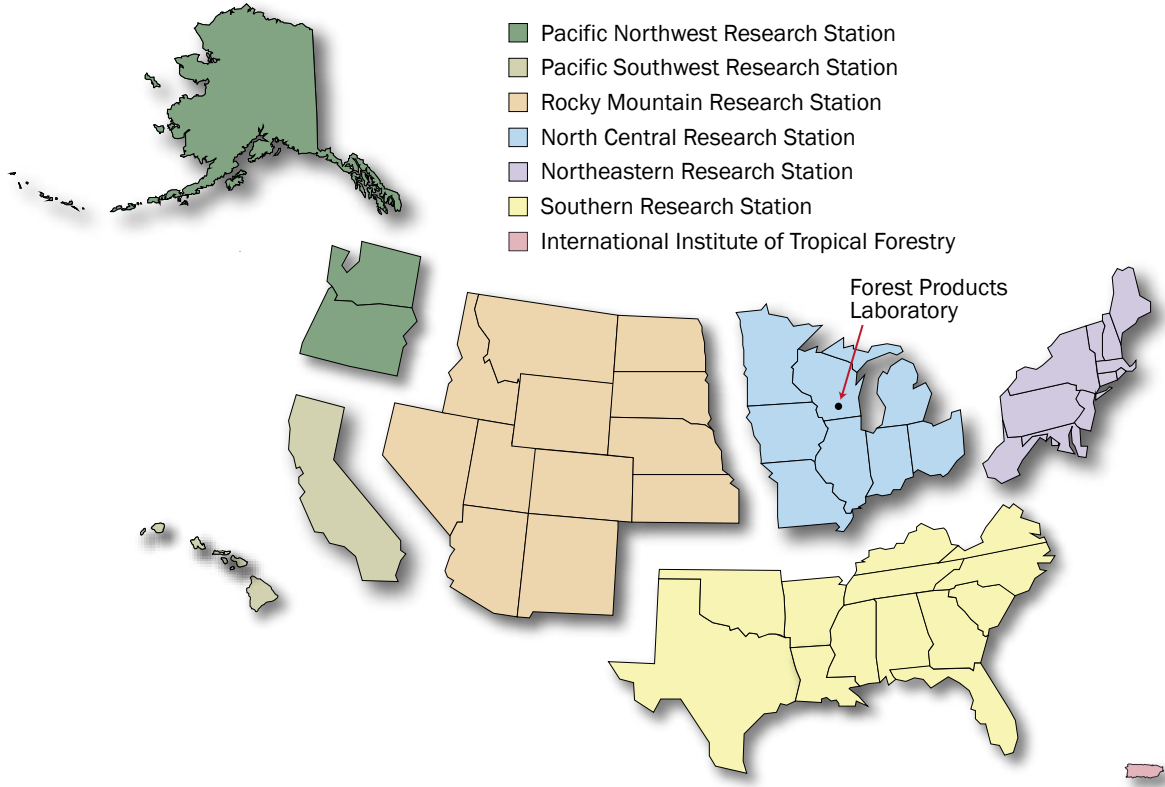
In closing, it has been a pleasure this past year to lead such a dedicated staff and work with our partners and constituents on common goals. I look forward to another busy, productive year in 2005.



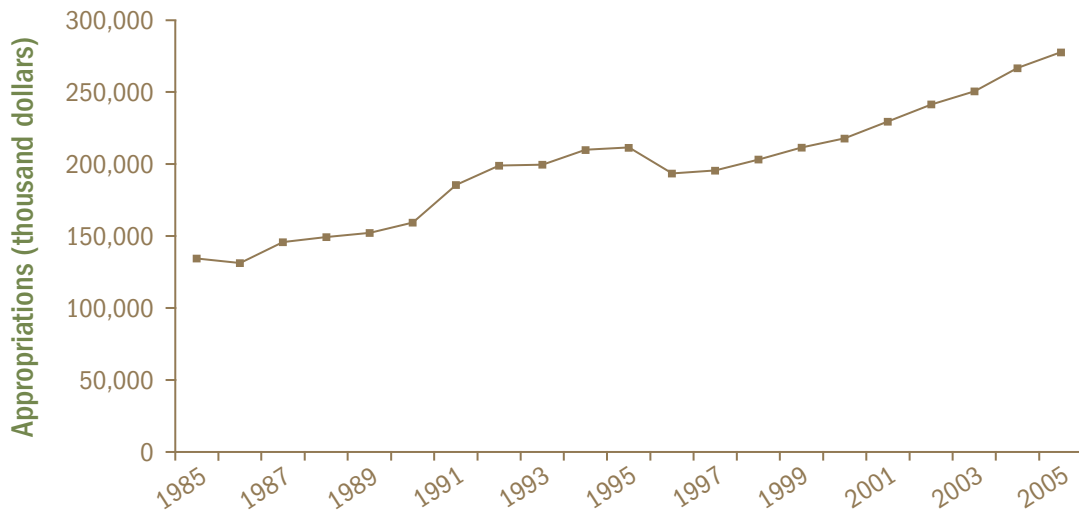
Ann M. Bartuska
Deputy Chief for Research and Development

RESEARCH AND DEVELOPMENT FACTS

USDA Forest Service Research Facilities



USDA Forest Service Research and Development Appropriations for the Past 20 Fiscal Years



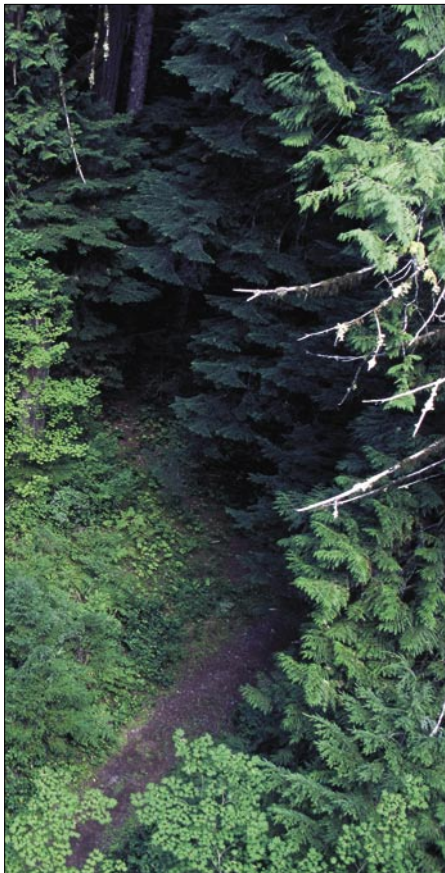
Scientists by Discipline

OFFICE OF PERSONNEL MANAGEMENT SERIES		1985	1990	1995	1997	2001	2002	2004	2005
0101	Social Scientist	9	8	17	12	18	17	17	15
0110	Economist	15	11	11	9	11	10	11	12
0150	Geographer	5	1	1	0	1	0	1	2
0193	Archeologist	0	0	0	0	3	2	1	1
0401	Biologist	30	13	14	13	14	17	19	18
0403	Microbiologist	14	9	14	10	10	9	6	7
0408	Ecologist	9	25	46	52	62	64	74	76
0410	Civil Engineer	6	1	0	0	0	0	0	0
0414	Entomologist	70	55	38	35	24	23	28	27
0430	Botanist	15	13	12	9	8	5	5	5
0434	Plant Pathologist	50	45	35	27	20	19	19	19
0435	Plant Physiologist	26	35	34	27	25	24	24	25
0437	Horticulturalist	2	1	4	0	0	0	0	0
0440	Geneticist	31	20	19	19	16	20	18	17
0454	Range Scientist	22	15	5	6	3	2	1	1
0460	Forester	350	230	138	143	134	128	126	119
0470	Soil Scientist	27	28	19	17	17	17	15	14
0482	Fishery Biologist	8	11	14	11	13	12	12	12
0486	Wildlife Biologist	42	44	44	41	37	35	31	28
0801	General Engineer	32	28	29	23	19	18	15	15
0806	Materials Engineer	0	0	0	0	0	0	0	3
0807	Landscape Architect	1	0	0	0	1	1	1	1
0808	Architect	1	0	0	0	0	0	0	0
0810	Supervisory Research Civil Engineer	0	0	0	0	1	1	0	0
0819	Environmental Engineer	0	0	0	0	0	0	0	0
0830	Mechanical Engineer	14	8	7	4	2	1	1	1
0855	Electrical Engineer	2	0	0	0	0	0	0	0
0893	Chemical Engineer	11	8	6	4	4	3	3	4
0896	Industrial Engineer	3	3	2	2	0	0	0	0
1301	Physical Scientist	3	3	5	5	5	3	5	5
1310	Physicist	5	3	2	1	1	1	1	1
1315	Hydrologist	19	21	13	13	12	12	7	6
1320	Chemist	41	21	21	16	18	18	17	14
1340	Meteorologist	12	9	9	9	9	8	8	7
1350	Geologist	5	4	4	5	3	3	3	3
1380	Forest Products Technologist	63	31	25	21	19	23	19	17
1515	Operations Research Analyst	7	2	0	0	0	0	1	0
1520	Mathematician	5	2	4	2	3	1	0	0
1529	Mathematical Statistician	30	16	14	11	11	10	12	10
1530	Biological Statistician	0	2	1	1	0	0	0	0
1550	Computer Scientist	0	0	0	0	0	0	1	1
Total:		985	726	607	548	524	507	503	486

RESEARCH AND DEVELOPMENT HIGHLIGHTS FOR 2004

Science at the U.S. Department of Agriculture (USDA) Forest Service has always been large in scale. The depth and breadth of the research conducted here, however, may surprise even many who are engaged in it.

Our research programs have a wide geographical and temporal scope, an interdisciplinary emphasis, and a steady focus on solving problems and informing sound policy, whether it addresses invasive insects, degraded river ecosystems, or sustainable ways to harvest timber. In short, USDA Forest Service scientists cover a lot of territory, in every sense of that phrase.



This report presents highlights from work conducted in 2004 by scientists in our Research and Development (R&D) Program. Our work is organized under seven broad themes: (1) fire, (2) invasive species, (3) recreation and social values, (4) water and air, (5) resource data and analysis, (6) wildlife and fish, and (7) renewable resource management and use and resource extraction.

These divisions, however, are not as tidy as they might seem. Our research studies take account of the interconnectedness of the ecological, economic, and social landscapes they examine, even as they tease apart pieces of it to add to the general sum of knowledge.

Here are just a few of the important topics covered in this report and the work our scientists are doing to address these issues.

Wildland Fire

- ▶ Developing a computer simulator to predict smoke pollution from prescribed fires.
- ▶ Comparing thinning, burning, and combination treatments for reducing the risk and severity of wildfire.
- ▶ Refining strategies for rehabilitating burned forests throughout the West.
- ▶ Mapping communities and lands in the wildland-urban interface (WUI) nationwide.

Invasive Species

- ▶ Developing a multipronged strategy to combat the emerald ash borer, an invasive pest that is killing ash trees in Michigan.

- ▶ Working with port authorities to stop exotic pests before they enter the United States.
- ▶ Developing a scientifically based method for assessing the threat of invasive plants to Hawaii's ecosystem and agricultural economy.

Recreational and Noncommodity Use of Lands

- ▶ Finding that "living memorials" created in public spaces after the 9/11 attack strengthen social unity and help maintain healthy communities after a crisis.
- ▶ Developing educational programs to encourage outdoor recreationists to treat the land with respect.
- ▶ Inventorying the amount and condition of forested recreation land in the United States.

Water Quality

- ▶ Developing ways to protect streams from runoff erosion after a severe wildfire.
- ▶ Exploring alternative land uses and buffer-strip recommendations to improve water quality along the Mississippi River.
- ▶ Synthesizing ecological knowledge of Great Basin watersheds to help landowners restore degraded riparian areas.

This 2004 R&D report is for our stakeholders, clients, and cooperators. We look forward to ongoing partnerships with them as we continue to produce knowledge and tools to meet the challenges of managing and protecting our varied and ever-changing landscape.

Wildland Fire



risk, suppressing fire where appropriate, mitigating smoke pollution, reducing flammable fuels, and interacting with communities.

The higher risk of wildfire, coupled with higher expectations for managers, has dramatically increased demands on the Wildland Fire R&D Program. This program provides practical knowledge and products that support managers in areas such as smoke modeling; fire suppression; fuel modeling and monitoring; biomass utilization; postfire restoration; efforts to understand the interactions of fire with climate; and prediction of fire's effects on insects and diseases, wildlife, and erosion. Wildland Fire R&D also helps managers seek the constructive involvement of people in communities at risk. Finally, our research enhances fundamental understanding of fire processes, interactions between fire and the forest ecosystem, and the social and economic aspects of fire management.

In addition to receiving our base R&D appropriation, Wildland Fire R&D receives support through research funding under the National Fire Plan and the Joint Fire Science Program. We coordinate our work to ensure that we address the highest priority areas and eliminate duplication of effort. Additional fire-related R&D, including research on water and air, silviculture, and insects and diseases, is carried out in other areas. USDA Forest Service R&D also cooperates with State and Private Forestry in its fire programs.



Jeff Kline

Mapping the Wildland-Urban Interface

The area where houses meet or intermingle with wildland

vegetation is called the wildland-urban interface (WUI). The WUI is not only a high-value environment for its human inhabitants, but it is also a focal area for conflicts between humans and the environment, such as wildland fires, habitat fragmentation, invasive species, and biodiversity decline. Until recently, however, we knew little about the size and behavior of this vital area.

Now, scientists from the North Central Research Station and the University of Wisconsin-Madison have produced the

Managing landscapes prone to wildfire is a complicated task that has become especially urgent with recent severe fire seasons. Under the National Fire Plan and the Healthy Forest Initiative and Healthy Forests Restoration Act, managers are implementing integrated, landscape-scale strategies for managing wildfire

valuable tool that can lower the risk of loss of life and damage to property from wildfires.

Partner: University of Wisconsin-Madison.

Lead: North Central Research Station.

Prioritizing Areas for Fuel Treatments

Over the past 100 years, natural fire cycles have been altered in fire-adapted ecosystems across large areas of the West, increasing the risk of severe wildland fire. The Healthy Forest Restoration Act aims to reduce hazardous fuels in these areas and restore ecosystem health and fire cycles to historical patterns. Such efforts are costly, and managers agree that the highest priority areas should be treated first. Until now, however, managers lacked an efficient and effective way to identify the areas of greatest need.

USDA Forest Service scientists have developed a new Web-based tool called the Fuel Treatment Evaluator (FTE). The tool uses data from the Forest Inventory and Analysis program to target areas that need thinning and areas that have departed from historical natural fire regimes. The tool displays the effects of alternative silvicultural thinning treatments and evaluates such treatments by calculating the acres on which fire risk is reduced, biomass yields and value, and

first nationwide, science-based maps depicting communities and lands in the WUI. Their project provides essential information on shifting human settlement patterns in the WUI, which, together

With these maps, land managers can see which areas are most at risk from fire and other disturbances.

with wildland fuels data, forms a solid scientific basis for fire preparedness and fuels management.

With these maps, land managers can see which areas are most at risk from fire and other disturbances. This knowledge helps them coordinate and prioritize hazard-mitigation projects and aid States and communities in their fire prevention and firefighting efforts. The maps provide a



Tom Iraci

characteristics that affect fire behavior, such as crown height and stand density.

The FTE is currently being used to assess the biomass potential from forests for the U.S. Department of Energy (DOE) Biomass Report. The assessment will become part of President George W. Bush's energy agenda. This new tool promises to reduce damage from wildfire by helping land managers prioritize opportunities to reduce hazardous fuels in forests throughout the Western United States.

Partners: USDA Forest Service—Forest Products Laboratory (FPL), Pacific Northwest and Rocky Mountain Research Stations.

Lead: North Central Research Station.

Thinning and Burning for Oak Regeneration

Majestic oaks still dominate hardwood forests in the Northeast as they have for thousands of years, but the next generation of oak seedlings and saplings is

significantly fewer acorns were infested with acorn weevils in the year after treatment. These preliminary results clearly indicate that thinning and burning are an effective combination for oak regeneration.

Lead: Northeastern Research Station.

Classifying Wildfire Fuel Characteristics

USDA Forest Service scientists have developed a Fuel Characteristic Classification System (FCCS) to more accurately capture the structural complexity of fuelbeds (combustible materials such as dry duff, stumps, snags, and live trees that are layered from the ground up to the canopy) throughout the United States. The FCCS has the following three components:



Measuring forest floor consumption after fire front has passed.

Roger Ottmar

The much-loved and economically valuable oak is losing out to competition from red maple, sugar maple, white ash, and beech in the forested landscape.

struggling to survive. The phenomenon, first noticed about 40 years ago, is known to scientists as “failed oak regeneration.” The much-loved and economically valuable oak is losing out to competition from red maple, sugar maple, white ash, and beech in the forested landscape.

In southern Ohio oak forests, Northeastern Research Station scientists tested four treatments to encourage regeneration: forest thinning, a one-time prescribed burning during the dormant season, a combination of thinning and burning, and no treatment at all.

The thinning/burning combination proved best. Oak seedlings on sites that had been thinned and burned germinated earlier and had bigger leaves, and

- ▶ A data library of fuel information for more than 170 fuelbed types.
- ▶ An expert system that enables users to select fuelbeds from general site data or to enhance classification by adding more details on fuel abundance, character, and distribution.
- ▶ A calculator that assigns a fire potential index reflecting the area's capacity for surface fire, crown fire, and fuel consumption.

The system was applied in prototype on two northwestern national forests in 2004. Related work included building a 0.62-mile Geographic Information System (GIS) layer of fuelbeds from the FCCS.

Because the fuelbed classification is explicitly linked to a database, it can be rapidly rebuilt as fuels data change and as better vegetation classifications are produced. The detailed fuels information provided by the FCCS will support fuel-treatment decisions and help improve

assessments of fire hazard. The FCCS also provides more accurate input for modeling of fire behavior and the effects of fire, such as smoke dispersion. The fuels layer provides input for regional-scale modeling of carbon dynamics and helps to validate emissions estimates based on satellite imagery. Visit <http://www.fs.fed.us/pnw/fera/jfsp/fcc/graphics.html> for a detailed FCCS diagram.

Partners: Joint Fire Science Program, National Fire Plan, University of Washington, USDA Forest Service—Pacific Northwest Region, U.S. Environmental Protection Agency (EPA).

Lead: Pacific Northwest Research Station.

Improving Evaluation of Fire Impacts

The BlueSky smoke prediction system, developed by scientists at the Pacific Northwest Research Station and a consortium of Federal, State, tribal, and university partners, links information on atmospheric processes with components of fuel structure, moisture dynamics, and fire characteristics to predict smoke impacts from wild and prescribed fires. The only tool of its kind available to



Tom Iraci

With BlueSky and other smoke management tools, incident command teams can issue more accurate smoke advisories to communities in Western States.

land managers, BlueSky has changed the way fire and smoke are managed in the Northwestern States and is being expanded to cover more land area and to provide more detailed results.

Recently, scientists modified the model to include information on prescribed burns from several State, private, and tribal agencies in addition to information about those conducted on Federal lands. The system also was modified to automatically include wildfire information from the nationwide incident status summaries (daily summaries of the status of wildland fires, issued by the National Fire Information Center in Boise, ID). BlueSky's scientists migrated the tool to the USDA Forest Service's other research stations and developed an extended version of the system that can simulate cumulative smoke impacts from wildfires in all Western States.

The inclusion of wildfires in the BlueSky system makes it immediately adaptable throughout the Nation, even in places that do not have a prescribed-fire monitoring program. The EPA is financing a version of BlueSky's Rapid Access Information System (RAINS) (<http://www.bluesky rains.org>) for Idaho, Oregon, Washington, and western Montana. This version combines the BlueSky system with the EPA's

Federal law requires managers to predict the impacts of prescribed fires (and wildfires) on regional air quality and to reduce human-caused contributions to regional haze.

This is difficult without good predictive tools.

RAINS technology to yield an interactive Web-based regional forecast of smoke concentrations.

Partners: EPA—National Centers for Environmental Prediction and Region 10, Office of Air Quality Planning and Standards, Office of Air and Radiation, Office of Environmental Information; Montana/Idaho State Airshed Group; Nez Perce, Quinault, and Colville Tribes; Northwest International Air Quality Environmental Science and Technology Consortium; Oregon Department of Forestry; University of Washington; USDA Forest Service—Pacific Northwest, Rocky Mountain, Southern, North Central, and Pacific Southwest Research Stations; Fire and Environmental Research Applications, Pacific Northwest and Northern Regions; U.S. Department of Commerce (DOC) National Oceanic and Atmospheric Administration (NOAA) National Weather Service; U.S. Department of the Interior (DOI) Bureau of Land Management (BLM) Washington, Oregon; Washington Departments of Ecology and Natural Resources; Washington State University.

Lead: Pacific Northwest Research Station.

impacts of prescribed fires (and wildfires) on regional air quality and to reduce human-caused contributions to regional haze. These tasks are difficult without good predictive tools.

The Fire Emission Production Simulator (FEPS), created by scientists from the Pacific Northwest Research Station, provides data on air-quality impacts from fires. FEPS is a user-friendly computer program that uses key characteristics of fires—consumption, emissions, and heat release—to predict the emission of pollutants and carbon from both prescribed fires and wildfires. The simulator, which can be used for most forest, shrub, and grassland types in the world, predicts total burn consumption and hourly emissions.



Jim Cronan, Yale University

Data obtained from collection of smoke samples after a crown fire will contribute to a computer model that estimates smoke and carbon emissions from wildfire.

Simulating Emissions From Prescribed and Wildland Fires

The decision on whether to allow a prescribed fire often hinges on the anticipated effects of the fire on air quality. Federal law requires managers to predict the

Users of FEPS can produce reasonable results by using default values and calculations, or they can customize the data for more refined results. The simulator dramatically improves the ability of regional air quality planners to quantify smoke effects. State planners, fire managers, and smoke management coordinators use FEPS daily to make decisions about whether and when to permit prescribed fires. State and regional air resource managers use FEPS to quantify smoke estimates during the planning process, to predict the emissions of air pollutants, and to make decisions about permitted prescribed fires.

Partners: Joint Fire Science Program, National Fire Plan, USDA Forest Service—Pacific Northwest Region.

Lead: Pacific Northwest Research Station.

Changing Climate Underpins Carbon Dioxide Emissions Law

A finding by USDA Forest Service scientists that global climate change would probably increase wildfires was one justification for a California law mandating lower levels of carbon dioxide emissions from sport utility vehicles.

Scientists from the Pacific Northwest Research Station studied the likely effects of climate change on wildfire behavior in California. They used a computer model to simulate a doubling of the 1990s level of carbon dioxide in the atmosphere.

They focused on three multicounty study areas in the northern portion of the State, and then interpolated the results to cover all of northern California's State Responsibility Areas (those areas where the State of California is responsible for suppressing fires).



Tom Iraci

They found that a doubling of atmospheric carbon dioxide would result in an additional 114 escaped fires per year. Using the average historical size of escaped fires—those that are never brought under control and die only when heavy rains come, usually in late fall or winter—they estimated that about 4 percent of the state responsibility area would burn each year, up from 2 percent under the present climate. This increased area is approximately the same amount that would burn if the average fire-return interval went from 50 years to 25 years.

The scientists' findings were part of the justification for a 2001 law that required light-duty trucks and most sport utility

vehicles to meet the same emission standards as passenger cars and that made the emissions standards for these vehicles more stringent beginning with the 2004 model. Study findings also were communicated to the State of California Energy Commission and the California Board of Forestry and are being used by the State's Department of Forestry and Fire Protection as it plans strategies for long-term changes in initial fire response.

Partner: Lawrence Berkeley National Laboratory.

Lead: Pacific Northwest Research Station.

Rehabilitating a Burned Forest

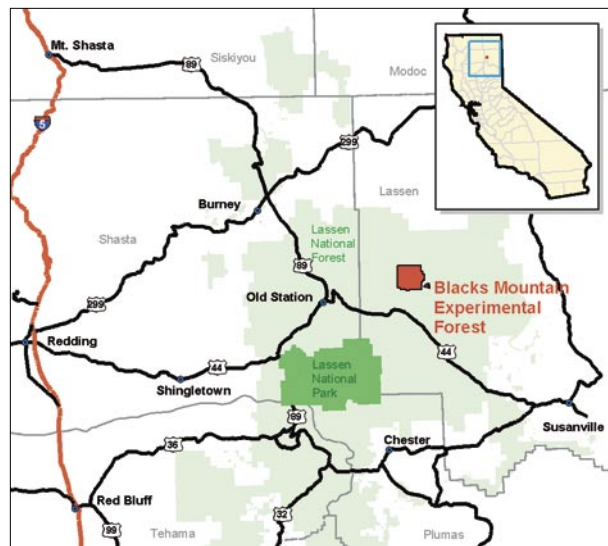
The Cone Fire burned more than 1,600 acres of California's Blacks Mountain Experimental Forest

in September 2002. After such a wildfire, forest managers must decide how to lessen the risk of another fire by salvaging burned trees for timber, replanting or regenerating the forest, and influencing the composition of the new growth.

In 2004, researchers from the Pacific Southwest Research Station, working closely with the Lassen National Forest, initiated several studies on the experimental forest to address these issues. Fire salvage at several levels of intensity took place on 1,317 acres, and 242,000 seedlings were subsequently planted on 800 acres of the burn.



Ongoing research plots will allow scientists to investigate the effects of salvage on soil compaction and on the subsequent development of fuels. Researchers will also look at the effects of thinning and prescribed fire on survival of remaining trees, how forest structures and diverse



natural vegetation develop in response to plantation spacing, and the most effective planting methods for interior ponderosa pine stands.

Research at Blacks Mountain is providing information for forest managers who are conducting fuels treatments and fire salvage as key components of their land management strategy. The project has become a demonstration site for the effectiveness of fuels treatments, with numerous field trips conducted for representatives from other agencies.

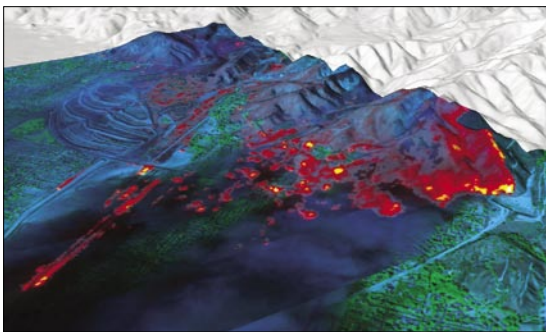
Partners: University of California Cooperative Extension; USDA Forest Service—Lassen National Forest, Eagle Lake Ranger District; Wildlife Conservation Society.

Lead: Pacific Southwest Research Station.



Providing Internet Intelligence for a Forest Under Siege

When massive wildfires struck southern California in October 2003, the Pacific Southwest Research Station uploaded hour-by-hour data to the Internet from its FireMapper® thermal-imaging radiometer during critical periods of major fires, including the devastating Old Fire in San Bernardino County and the Cedar Fire in San Diego County.



The Pacific Southwest Research Station collected data on the progress and intensity of the fires from the station's Airborne Sciences Aircraft, uplinked it by satellite communication, georeferenced it to a map base, and posted it on the World Wide Web, where it was accessible to fire operations personnel in as little as 90 minutes.

The Pacific Southwest Research Station is partnering with Space Instruments, Inc., to develop and apply the FireMapper® for strategic fire mapping. Their aim is to improve fire-suppression operations and firefighter safety and to enhance understanding of the behavior and impacts of wildland fire. FireMapper® uses new night-vision technology to measure thermal radiation from spot fires and intense flaming fronts alike. Resulting data provide a detailed view of fire spread that has not previously been available to fire managers.

Partners: Space Instruments, Inc.; USDA Forest Service—Pacific Southwest Region.

Lead: Pacific Southwest Research Station.

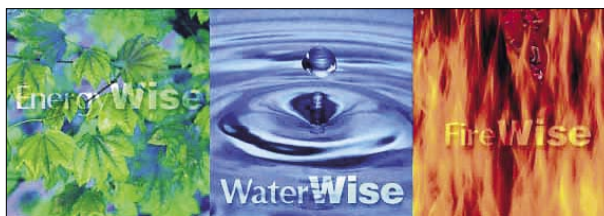
The computer model enables users to simulate the placement of homes on their lots and interactively add, remove, grow, and prune trees.

Helping Homeowners Assess Threat From Wildfires

Millions of homes in WUI zones are at risk from wildland fires. The Center for Urban Forest Research at the Pacific Southwest Research Station developed a new computer model to help residents in

WUI zones protect their property from wildfire. The model guides residents in making fire-safe landscaping choices while enhancing the beauty of their property, retaining native vegetation, providing privacy, conserving water, and saving energy.

The computer model enables users to simulate the placement of homes on their lots and interactively add, remove, grow, and prune trees. Risk of fire is indicated by a bar that turns from green (low) to red (high), as the model calculates the radiant heat on the house that would occur under each scenario.



The fire-behavior principles behind the software are based on research conducted at the National Institute of Standards and Technology (NIST). The fire model is being coupled with a similar energy-assessment module (EnergyWise) and water model (WaterWise) to estimate effects of vegetation placement on stormwater runoff, landscape water use, and energy use. The fire model is available for use at <http://www.ecoSmart.gov>.

Partners: California Department of Forestry and Fire Protection, Earthview Computing, NIST, TreePeople, USDA Natural Resources Conservation Service.

Lead: Pacific Southwest Research Station.

Improving Wildland Fire Decision-Support Software

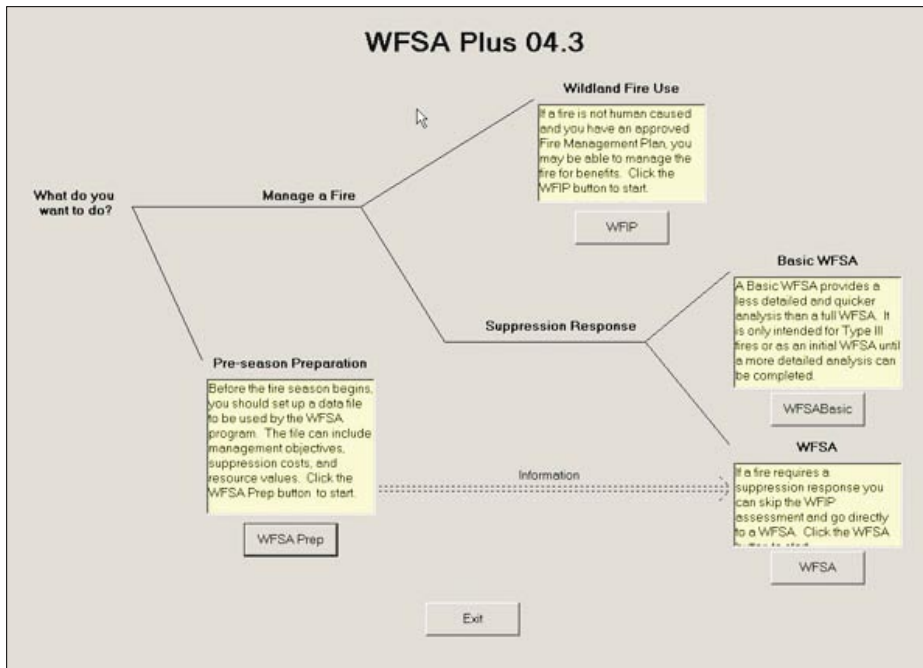
The Nation spends about \$1.5 billion in Federal wildland fire suppression each year. When a fire is raging, managers have to analyze economic data and make informed decisions fast.

An automated tool called Wildland Fire Situation Analysis (WFSA) is currently used by all Federal wildland fire agencies and some State fire agencies. In spring 2004, updated software was released that streamlines the analysis of the situation at the start of a fire, when time, resources, and complete information are in limited supply. The upgrade was developed by the Riverside Fire Lab (Pacific Southwest Research Station) and Balance Technologies, Inc.

The improvements to the standard WFSA provide fire managers with more guidelines to consider when estimating incident costs, and additional space to convey reasons for the decisions made. Analysts and agency administrators were trained in the use of the revised WFSA software in several workshops held around the country. This tool will help save lives and money, particularly in the WUI. More information on the tool can be found at <http://www.fs.fed.us/fire/wfsa>.

Partners: Balance Technologies, Inc.; USDA Forest Service.

Lead: Pacific Southwest Research Station.



Wildland Fire Situation Analysis (WFS).

Forecasting Fire Weather and Smoke Dispersion

The USDA Forest Service's Rocky Mountain Center provides comprehensive, real-time, high-resolution fire weather information and smoke forecasts for the interior West. The center's products help fire managers, incident commanders, and air-resource smoke specialists gather essential information during periods of intense firefighting and prescribed burning.

Their products include spatial maps and animations of predicted fire weather and fire indexes (up to 72 hours into the future), forecasts of fire weather and fire indexes at user-specified locations, long-term verification of fire-weather predictions at regional and point levels, and weather information that can tell fire managers when firefighters may be in danger because of a weather constraint. All products are delivered 24 hours a day, 7 days a week through the World Wide Web (<http://fireweather.info>).

Managers decided to forgo contour-felled log treatments over much of the area because the model predicted only marginal benefits. Such decisions can save millions of dollars.

The Rocky Mountain Center is a member of the Fire Consortia for Advanced Modeling of Meteorology and Smoke (<http://www.fs.fed.us/fcamms/>). It is funded by the National Fire Plan, the Rocky Mountain Research Station, and the NOAA Forecast Systems Laboratory in Boulder, CO. Center forecasting activities are located at the Rocky Mountain Research Station headquarters in Fort Collins, CO.

Partners: DOC NOAA—Forecast Systems Laboratory; Fire Consortia for Advanced Modeling of Meteorology and Smoke; National Interagency Fire Center—Southwest Area Coordination Center; USDA Forest Service—National Forest System (NFS), Pacific Northwest Research Station.

Lead: Rocky Mountain Research Station.

Predicting Postfire Runoff and Erosion

Large wildfires in mountain watersheds can lead to increased erosion and debris torrents, potentially degrading water quality and harming sensitive species. Costly emergency rehabilitation programs may mitigate these events, but their effectiveness is debated by scientists.

Scientists at the Rocky Mountain Research Station have developed new information to help managers understand the costs and benefits of such work. A new model known as Fire Enhancement Runoff and Gully Initiation (FERGI) uses measures of topography, soils, fire severity, weather, and proposed treatments to predict changes in stream runoff and erosion following a severe fire. The model

allows managers to determine where treatments may be useful and where they may not.

Over the past 2 years, station scientists worked with the Boise National Forest to analyze three wildfires in Idaho. Managers decided to forgo contour-felled log treatments (placing log erosion barriers) over much of the area because the model



predicted only marginal benefits. Such decisions can save millions of dollars and allow managers to focus on other work supporting more resilient aquatic systems. Subsequent thunderstorms produced massive debris flows in these watersheds that no treatment could have contained, underscoring the effectiveness of the model in supporting the decision process.



Charlie Luce, Rocky Mountain Research Station

A Web-based application is in development. Managers and specialists may find a link to the latest information on fire and aquatic ecosystems at <http://www.fs.fed.us/rm/boise/teams/fisheries/fire/firehome.htm>.

Partners: Columbia University, Oregon State University, University of British Columbia, University of Colorado, USDA Forest Service—NFS, Utah State University.

Lead: Rocky Mountain Research Station.

Stemming Runoff From Burned Watersheds

Millions of dollars are spent each year on emergency rehabilitation of forest watersheds burned in wildfires. Scientists have been installing small watershed studies following major fires throughout the West to determine the efficacy of rehabilitation treatments.

Rocky Mountain Research Station scientists initiated two sets of three small watershed studies following the 2002 Hayman Fire in Colorado. The objective was to compare the sediment generated from burned untreated hillslopes to that generated from burned hillslopes treated in various ways to reduce runoff and erosion.

The first set of experiments compared the amount of sediment from an untreated watershed to that from watersheds treated with hydromulch (a special blend of mulch seed fertilizer and cellulose) and with straw mulch. Little erosion occurred during spring snowmelt for any treated or untreated watersheds; however, in summer 2003, after four major storm events, the least erosion occurred on the watershed treated with straw mulch. The hydromulch decomposed before the storms occurred, and the hydromulch-treated watershed experienced more erosion than the straw-mulch-treated watershed.

In the second study, one watershed was treated with contour-felled logs to contain erosion, one was salvage logged, and one was left untreated as a control. The salvage logging was completed in fall 2003. The first storm that generated any erosion following salvage logging did not occur until July 2004. Data analysis is ongoing, but it is apparent that in this storm, the least erosion occurred from the contour-felled logs. When both study sites are combined, the straw-mulch-treated watershed had the least erosion especially during higher intensity rainfall events. Results of this work are helping resource specialists develop effective plans for mitigating erosion following wildfires. Learn more about this research at <http://forest.moscowfsl.wsu.edu/index.html>.

Partners: DOI BLM; USDA Forest Service—NFS, Pacific Southwest Research Station; Viejas Tribe.

Lead: Rocky Mountain Research Station.



Tom Iraci

Thinning, Burning, or Both?

Reducing fuels to lower the wildfire risk in fire-prone

forests has become an important objective for forest managers. The major tools at their disposal are prescribed fire and mechanical thinning, but these tools may be used together or separately, at a variety of levels of intensity. How do the various combinations of treatments affect the forest ecosystem?

The Southern Research Station (SRS) has been conducting a series of experimental treatments in cooperation with State agencies and universities in the southern Appalachians and Piedmont regions. The studies compare how prescribed fire, mechanical thinning, and a combination of thinning and burning affect forest species and ecosystem components—many more than have been studied before, including soils; insects; microbes; and avian,



Fire and fire surrogate studies yield information for decisionmaking for fuel reduction projects.

reptile, amphibian, and rodent communities. Preliminary results suggest that each treatment produces distinctive differences in vegetation, forest floor structure, wildlife habitat, and soils.

The final results will provide an overview of how various combinations of treatments affect a host of ecosystem functions, wildlife species, and forest



resources. Public and private land managers can use this information to guide them in their land management actions.

Partners: *Clemson University, University of Georgia.*

Lead: *Southern Research Station.*

Lowering Fire Risk With Knowledge and Tools

Policy makers, natural resource professionals, and citizens all are interested in lowering the risk of wildfire to homes and other resources in the WUI. In 2004, the Southern Center for Wildland-Urban

Interface Research and Information in Gainesville, FL, provided extensive scientific information and tools to help lower the risk of damage from wildfire. The primary focus was on National Fire Plan publications and Web-based products that highlight important fire issues in the Southern United States.

In 2005, a key technology-transfer project is the factsheet series titled “Fire in the Interface,” which includes factsheets on fire in Florida’s ecosystems, understanding fire behavior, selecting and maintaining firewise plants for landscaping, fuel-mitigation techniques for private

landowners, reducing wildfire risk while achieving other landscaping goals, and preparing a firewise landscape list. A homeowner’s guide to wildfire risk assessment is also provided.

In addition, the center produces the “InterfaceSouth Update,” a biweekly electronic bulletin about critical WUI issues, and it has developed the Firewise Retrofit House Online Module, which demonstrates how to retrofit a Florida home to make it and the surrounding yard firewise.

Finally, to facilitate the broader dissemination of ideas, a central World Wide Web location describing wildfire protection programs adopted by communities across the country was developed by the center’s Tax and Economics unit in New Orleans (<http://www.wildfireprograms.usda.gov>). The database provides a clearinghouse of information about the risk-reduction strategies other communities are implementing. The Web site can be searched by State, program objective, or administrative jurisdiction—State, county, city/town, or fire district.

Partners: *Louisiana State University, Southern Group of State Foresters, University of Florida.*

Lead: *Southern Research Station.*

Invasive Species

Frank Vanni



Invasive plants, insects, and pathogens pose one of the most serious environmental and economic threats facing the Nation. The number of invasive organisms in the United States has increased as international travel and trade have flourished, resulting in the loss of

native species, the disruption of ecosystems, and the diminishment of goods and services from forests and rangelands. USDA Forest Service R&D is conducting a wide range of research to help inform management activities, determine the magnitude of the problem, and improve control efforts.

Studies are investigating the biology of invasive species, options for environmentally safe control, methods for assessing risk, the role of disturbances in facilitating invasion of both exotic and native species, and impacts on native plants and animals (including threatened and endangered species) and aquatic and terrestrial ecosystems. Researchers are also developing programs for detection, inventory, and monitoring of invasive species, strategies for restoration and rehabilitation, and educational programs. Our goal is to develop new knowledge and technology that will improve management by (1) preventing invasive species introduction and spread, (2) controlling the most threatening invasives, (3) monitoring to detect newly introduced species, and (4) restoring ecosystems damaged by invasive plants, insects, or pathogens. Our efforts will contribute to improved functioning of forest and rangeland ecosystems nationwide, especially as invasive species management becomes a component of long-term landscape restoration.

Ash is a common and well-loved urban shade tree: it grows extensively in cities and towns across the United States. It faces an imminent threat, however, by the emerald ash borer, an aggressive invasive insect.

Fighting the Emerald Ash Borer

Ash is a common and well-loved urban shade tree: it grows extensively in cities and towns across the United States. It faces an imminent threat, however, in



the emerald ash borer, an aggressive invasive insect. The emerald ash borer infested and killed thousands of ash

trees in southeastern Michigan in July 2002. The pest is spreading rapidly and could infest more than a billion ash trees growing in the United States.



About 800 million ash trees grow in Michigan. The emerald ash borer continues to spread from Michigan's urban areas into productive rural forests. North Central Research Station scientists have made it a priority to detect, contain, and prevent the spread of the insect. They have identified how the pest spreads from tree to tree, and they are testing various insects and microbes to see if they might provide natural protection to ash trees. The scientists are also investigating natural enemies and predators of the ash borer in search of a possible biological control. They have also developed recommendations to safely dispose of infected trees and limit the spread of the pest.

North Central Research Station scientists continue to provide the best science information to combat this invasive pest. Their work is increasing the effectiveness of State and international control efforts and limiting the spread of the pest by humans.

Partners: Canadian Food Inspection Agency, Canadian Forest Service, Michigan Department of Agriculture, Michigan State University, Michigan Technological University, Ohio Department of Agriculture, Ohio State University, University of Illinois, University of Michigan, USDA Animal and Plant Health Inspection Service (APHIS).

Lead: North Central Research Station.

Halting the Spread of Invasive Pests

Most invasive insect pests are intercepted on imported food and cut flowers, but many are also found on wood packing materials such as pallets and crating. Many of the exotic (nonnative) bark- and wood-feeding insects now established in the United States, such as the emerald ash borer and Asian longhorned beetle, likely entered the country inside infested wood packing materials. One step in the prevention of exotic pests is to track down which foreign ports they depart from and where they enter the United States.

North Central Research Station scientists, in collaboration with USDA APHIS, analyzed records kept by port authorities of interceptions of bark beetles and ambrosia beetles between 1985 and 2000.

Then they mapped these interceptions to provide port inspectors with a visual tool for rapidly spotting trends and identifying new ports of entry.



Asian longhorned beetle.

For the first time, managers at USDA APHIS and State agencies can see at a glance the patterns of distribution of exotic insects. Such interactive tools can help direct resources to halt wood-boring insects at the border before they can enter and attack America's forests.

Partner: USDA APHIS.

Lead: North Central Research Station.

Controlling Hemlock Woolly Adelgid

The hemlock woolly adelgid (HWA) is an exotic (nonnative) insect with no natural enemies in its adopted habitat—a very threatening invasive species. The HWA is a serious problem in the Northeast, where half the native range of eastern hemlock is infested. Scientists at the USDA Forest Service's super-secure quarantine laboratory in Ansonia, CT, are working to improve techniques to detect, track, and control the adelgid.

Scientists found a previously unknown type of lady beetle that dramatically reduces HWA populations at that critical period before they become a full-blown infestation. They also discovered that the adelgid harbors bacteria on its abdomen, and new research is focusing on ways to use those organisms as vehicles for HWA control. Scientists believe these various biocontrols could work together to maintain populations at less damaging levels.

Station scientists also discovered that adelgid-susceptible hemlocks in the

Scientists found a previously unknown type of lady beetle that dramatically reduces hemlock woolly adelgid populations at that critical period before they become a full-blown infestation.

Eastern United States have a different biochemical makeup than resilient hemlocks in Asia and the Western United States, which is helping improve early detection efforts.

Lead: Northeastern Research Station.

Identifying Disease Resistance in American Beech Trees

In the 1930s, beech bark disease (BBD) was accidentally introduced in Maine and has slowly spread south along the eastern seaboard. Its discovery in Ohio threatens American beech trees in the Midwest.

Northeastern Research Station scientists discovered the first case of deadly BBD in Ohio in 2004, including one confirmed case at a local arboretum. As a result, they intensified their program to identify disease-resistant beech trees, with tremendous results. A Northeastern Research Station scientist cross-fertilized seeds of beech trees that survived BBD and found that half the new offspring are resistant to the disease. This good news shows that resistance is an inheritable trait and not just a stroke of luck among a narrow beech population.

Lead: Northeastern Research Station.

Fine-Tuning the Timing of Prescribed Burns

Prescribed fire is a major tool used to reduce fuel loads and restore ecosystem functions in low- and mid-elevation ponderosa pine forests in the Blue Mountains of eastern Oregon and Washington.

These prescribed burns, however, can affect more than just the accumulation of understory growth. Scientists studied the effects on ecological processes of underburning in fall, when fires historically occurred in the region, and in spring, when most prescribed burns currently occur.

Fall burning affects ectomycorrhizal fungi more than spring burning does. Ectomycorrhizal fungi are root-dwelling organisms in forests that help trees take in nutrients and resist drought stress. Although we know the important role



Mark Reid

of these fungi, much remains unknown about their community structure and their response to fire. In a study in eastern Oregon, scientists found that fall underburning killed live tree roots to a depth of 4 inches and significantly reduced species richness of ectomycorrhizal fungi compared to spring underburns for at least 2 years after the burn.

Partners: USDA Forest Service—Malheur National Forest Emigrant Creek Ranger District and Migrant Creek Ranger District, Pacific Northwest Region, Pacific Southwest and Rocky Mountain Research Stations.

Lead: Pacific Northwest Research Station.

Reducing Hazardous Fuels and Bark Beetle Activity

Under the National Fire Plan and other policy initiatives, programs to reduce hazardous fuels in forests have dramatically increased, and fuel reduction will likely continue in the future. Much of the biomass generated by these treatments, however, is not merchantable.

Many land managers like the technique of chipping to dispose of the slash because the biomass decomposes on the site, helping to retain nutrients. Leaving chips on the site, however, may increase the risk of infestation of the residual trees by pine bark beetles, which could eventually kill them.

Researchers at the Pacific Southwest Research Station compared the effects of chipping and other slash-disposal



techniques on the amount and distribution of tree mortality caused by bark beetles in ponderosa pine forests. Four treatments were used: areas that were chipped and scattered, areas that were chipped and bases raked, areas that were lopped and scattered, and areas that were left untreated and used as a control. Chips were removed from all sites that were chipped. Preliminary results indicate that chipping increased the amount of subsequent bark beetle activity, but removing the chips from the bases of residual trees significantly reduced the number of attacks. They also found that treatments conducted in the spring resulted in significantly more bark beetle attacks than those done in the fall. This research will help forest managers maintain healthy forests and reduce fuels.

Partners: USDA Forest Service—Pacific Southwest and Southwestern Regions.

Lead: Pacific Southwest Research Station.

Halting Sudden Oak Death

Sudden Oak Death (SOD) is a serious disease that attacks trees and many other forest, landscaping, and farm plants in coastal California and Oregon. The disease worries researchers and the public alike because of its rapid spread, its wide range of hosts (rhododendron, azalea, blueberry, cranberry, heather, pieris, and several others), and its potential economic impact on nurseries and small farms.

SOD first appeared in California true oaks and tanoaks in 1995. It was subsequently discovered in Oregon and Washington; more recently, it has surfaced at other locations in the Eastern United States. Scientists at the Pacific Southwest Research Station are collaborating with many others to get answers on what the disease does to its host plants, how it spreads, and what measures effectively control it.

Caused by a fungus-like organism, SOD blotches a plant's leaves and causes stems and twigs to die back. Some very susceptible plants die. Researchers have found that climate plays a major role in the survival and spread of the disease; moist and cool weather is optimal. California bay laurel, a leaf host and possible source of inoculation, plays a significant role in the spread of SOD in California. Green waste from composting is a potential source of long-range spread, but controlled experiments demonstrated that heating the compost to a certain temperature for a certain length of time will destroy live spores and sanitize the waste. Such information is critical for developing management strategies, quarantine regulations, and risk models.

A chemical treatment has been registered for use against the pathogen and will prevent infection or retard canker growth. Scientists are also examining the potential of runoff water to carry the infection, the potential for spread from windblown compost piles, and effectiveness of the treatment in all areas of the compost pile.

Partners: California Oak Mortality Task Force; many additional Federal and State agencies, universities, and organizations worldwide.

Lead: Pacific Southwest Research Station.

Assessing Risk for Exotic Plants in the Pacific Islands

Hawaii has the most endangered species, as well as the most severe invasion of exotic plants in the country. The islands' flora contains more than 1,000 species of naturalized exotic plants, many of which have had dramatic ecological, as well as economic, impacts. Invasive species result in the decline in native forest species, speed the decline of rare species toward extinction, increase wildfires, and reduce agricultural productivity. The threat from invasive plants is growing in Hawaii owing to increased trade and commerce in the new global economy.



Monica calvenscens (invasive).



Plumeria obtusa (endangered species).

Tools to evaluate the potential danger of alien plants need to be developed. We must recognize which introduced species will cause ecological and economic costs, and provide understandable, science-based, documented evaluations recognized as reliable by all stakeholders.

The Pacific Southwest Research Station adapted and evaluated the Australian/New Zealand Weed Risk Assessment protocol for use in Hawaii and other Pacific islands. This tool provides a reliable, documented, scientifically based method of assessing potential impacts of exotic species on natural and agricultural ecosystems. It provides agencies and managers with a basis for setting priorities for control and prevention. The

protocol is being used by the State of Hawaii to develop outreach programs to the horticultural industry to reduce sale of potentially invasive species.

Partners: Hawaii Conservation Alliance; Hawaii Division of Forestry and Wildlife, Kaulunani Urban and Community Forestry Program; State of Hawaii; University of Hawaii, Department of Botany; USDA Forest Service—International Programs.

Lead: Pacific Southwest Research Station.

Battling Cheatgrass With Fungus

Cheatgrass is an annual invasive weed that has infested large areas in the Western United States, particularly in

mechanism, causing it to produce fungal smut spores rather than cheatgrass seeds. Studies of these organisms' ecological adaptation and molecular genetics show that the cheatgrass headsmut fungus has minimal potential to harm indigenous perennial grasses. Continuing studies are promising.

Learn more about research at the Provo Laboratory at <http://www.fs.fed.us/rm/provo/>.

Partners: Brigham Young University, DOI BLM, Idaho National Guard.

Lead: Rocky Mountain Research Station.

Once cheatgrass has taken hold, it is unlikely that the native vegetation will recover.

the big sagebrush and pinyon-juniper ecosystems. The presence of fine fuels has dramatically shortened the fire-return intervals in these ecosystems, and more frequent fire has effectively removed the dominant native woody plants from their habitats over vast acreages. This removal has paved the way for invasion by other weedy species, including the highly resilient cheatgrass. Once cheatgrass has taken hold, it is unlikely that the native vegetation will recover. Scientists believe that some means of controlling cheatgrass is imperative if the natural woody ecosystems are to be restored.

Scientists from the Rocky Mountain Research Station in Provo, UT, are investigating the potential biological control of cheatgrass by a naturally occurring headsmut fungus (*Ustilago bullata*). This fungus infects cheatgrass at the seed-germination phase of its life cycle and eventually takes over its reproduction

Combating Invasive Plants Through Effective Outreach

A new USDA Forest Service technology-transfer effort aimed at combating non-native invasive plants has had widespread



Cheatgrass.

impact across the Southern United States. Its centerpiece is a guidebook produced by the Southern Research Station, *Nonnative Invasive Plants of Southern Forests: A Field Guide for Identification and Control* (GTR-SRS-62), which was introduced at a June 2004 regional workshop held in Greenville, SC, that attracted 220 participants.



The guidebook, which presents the latest information on invasive species to landowners, managers, policymakers, and consultants, was followed by a revised edition and expanded printing. In total, 50,000 copies of the book were requested and distributed in fiscal year (FY) 2004 through a concerted effort by the Regional Extension Forester, the Southern Research Station, and Forest Health Protection. Electronic versions were also downloaded through the Southern Research Station and <http://www.invasive.org> Web sites.

Nearly all Federal and State land management agencies in the South were involved in the distribution of the guidebook. Through cooperation with the DOI's U.S. Fish & Wildlife Service (USFWS) and National Park Service (NPS), the book was distributed to managers and staff of most preserves and parks. The book is also being used as a survey tool in invasive-plant eradication and native-plant restoration programs in Federal, county, and city parks.

This book assisted the rapid formulation and recent adoption of the Southern Region Invasive Species Strategic Plan, and will be used to support initial efforts to survey and control invasive species on national forests. It continues to be used by surveyors to implement the only invasive-plant survey in the Nation, conducted by the Southern Research Station

and State agency partners on forests under all ownerships in the region. Data from this survey will soon be available to support program development at all levels, from national to local, and to focus research into the abundance and distribution of invasive species.

Partners: *USDA Forest Service—Forest Health Protection, Regional Extension Forester.*

Lead: *Southern Research Station.*

Protecting an Experimental Forest From an Aggressive Invader

Decades of research on sustainable forestry at the Bent Creek Experimental Forest in North Carolina are being threatened by the noxious weed oriental bittersweet. The woody vine is aggressive and highly adaptable—it grows on all kinds of sites and will tolerate shade, but grows even faster in the sun. In the summer of

2004, volunteers spent 7 workdays to help eradicate it on part of the Bent Creek Experimental Forest.

Herbicides have proven to be more effective than hand pulling because root fragments left in the ground will resprout. Volunteers in the Bent Creek Bittersweet Sweep hand-pulled and bagged plants near streams to protect them from herbicide residues. Away from streams, they sprayed trichlopyr on leaves of the plant and treated some stumps with the same chemical. Volunteers were trained to identify bittersweet and other prominent pest plants while learning about invasive plants and control methods. Certified herbicide specialists provided training on herbicide application and safety. More than 38 people took part in the effort for nearly 200 volunteer hours.

Partners: *North Carolina Department of Natural Resources; USDA Forest Service—Forest Health Protection, Regional Extension Forester.*

Lead: *Southern Research Station.*



Volunteer assists with oriental bittersweet sweep at Bent Creek Experimental Forest.

Research in the tropical forests of Puerto Rico suggests that “exotic” does not always mean “harmful.”

Identifying the Relationship Between Bark Beetles and Their Fungi

Bark beetles are a destructive biological force in North American forests. They attack and kill living trees, live in and feed on weakened trees, and facilitate the decomposition of dead tissues. These insects all carry fungi capable of killing or damaging trees, but the roles these fungi play in the beetles' biology is not well understood. Recently completed research revealed the following:

- ▶ Wasps that parasitize southern pine beetles are attracted to the smell of the fungi carried by these beetles.
- ▶ Fungi can successfully compete with southern pine beetles for tree tissue, contributing to the collapse of beetle populations.
- ▶ Fungi that benefit southern pine beetles compete with other fungi that harm the beetles; the outcome of this competition depends on the water status of the host.
- ▶ Root beetles associated with decline of loblolly pine produce more offspring when they carry pathogenic fungi into the roots with them.
- ▶ Less aggressive bark beetles are also affected by the fungi they carry.

This research contributes directly to knowledge of the dynamics between southern pine ecosystems and native invasive insects. Nonnative insects are likely to have similar interactions with fungi. This research was reported in *Science* and eight other peer-reviewed outlets in FY 2004 and was the subject of an international presentation. Findings



Control of invasive bark beetles is improved by understanding roles of fungi in their biology.

are being incorporated into improved models of bark beetle population growth and decline. These models will give forest managers more accurate ways to predict beetle activity and identify effective management practices.

Partners: Dartmouth College, Louisiana State University, University of Georgia, University of Wisconsin–Madison.

Lead: Southern Research Station.

Forming New Ecosystems With Nonnative Tree Species

The invasive potential of nonnative species is a source of concern in many landscapes, but research in the tropical forests of Puerto Rico suggests that nonnative does not always mean “harmful.” Sometimes nonnative plants colonize and improve the productivity of degraded sites and help the native plants return.

Exotic tree species account for more than 25 percent of the tree species in the tropical forests of Puerto Rico. Their importance has increased since 1980 when the first inventory was conducted. The most common of these species, the African tulip tree, readily invades abandoned agricultural lands, where it helps improve the soil and microclimate and facilitates the reestablishment of native tree species.

African tulip trees remain on site for at least 80 years. They are now forming new forest ecosystems characterized by a mixture of native and nonnative tree species. The wildlife that inhabited the native forests is also part of these new forest types, which appear to function similarly to native forests.

Novel environmental conditions may sometimes lead to novel ecosystem composition while maintaining ecosystem function. This research suggests that the ecological role of nonnative species requires study before implementing costly eradication programs.

Partners: Puerto Rico Conservation Foundation; USDA Forest Service—International Institute of Tropical Forestry, Southern Research Station.

Lead: International Institute of Tropical Forestry.



African tulip tree (Spathodea campanulata).

Ariel Lugo

Recreation and Social Values



The Recreation Research Program provides scientifically sound information, tools, and other research services pertaining to the recreational use of public forests and other public lands, supply and demand of recreational opportunities, impacts of recreation on local communities, and effects of resource management and landscape change on recreational activities. The objective of our research is to help managers, communities, and other stakeholders better understand the risks, trends, and emerging issues affecting recreation so that they may develop credible

and defensible plans, monitoring protocols, and policies to effectively manage outdoor recreation. Ultimately, our goal is to help provide recreational opportunities that meet users' needs and expectations while sustaining healthy ecosystems.

“Living memorials” play a role in strengthening social unity and maintaining healthy communities after a crisis.

Easing Grief and Building Community After 9/11 With “Living Memorials”

“Living memorials” play a role in strengthening social unity and maintaining healthy communities after a crisis. Social scientists from the Northeastern Research Station in Burlington, VT, and from New York City began research of 200 public spaces in the United States and Puerto Rico that were created, used, or enhanced in memory of the tragic events of September 11, 2001.

They found that the purpose of most memorial projects was to remember all victims of September 11; to serve the local community; and to create a place of comfort, solace, peace, and safety. About 40 percent were located in parks and 25 percent on civic grounds; 18 percent consisted of community gardens.

Observations from the first year revealed one common theme: “We must never forget.” According to researcher Erika Svendsen, people sought a physical space as a substitute for the gravesite; they also wanted to remember the living. She also concluded that people experiencing

post-September 11 stress created living memorials simply to regain a feeling of control. Of the people questioned, about 70 percent believe the memorial site had become a sacred space.

The second year of research will focus on the contributions of public space in our

communities to collective health and resilience.

Partner: New York City.

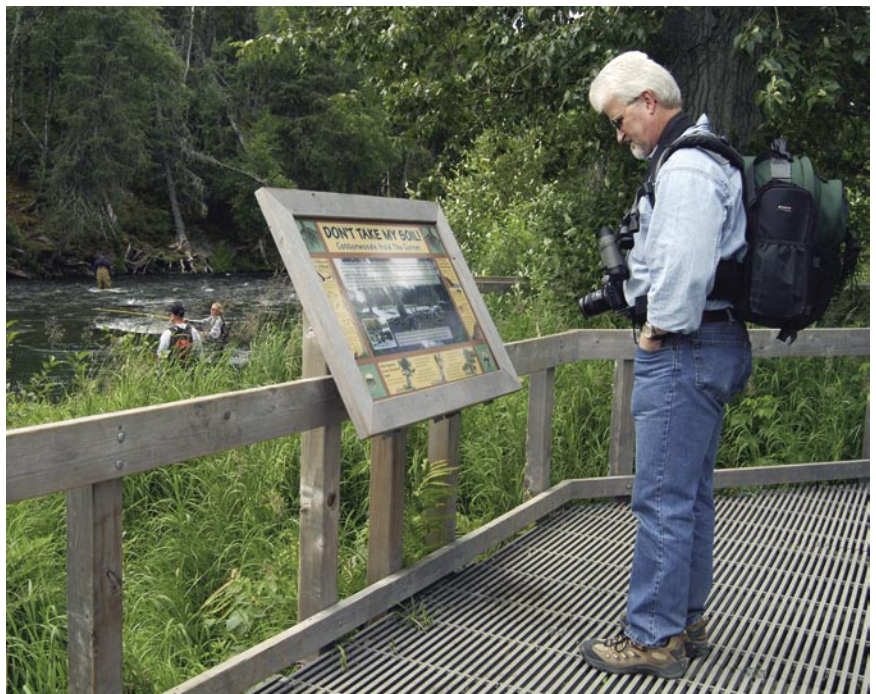
Lead: Northeastern Research Station.

Providing Positive Experiences of Solitude

Is solitude a pleasant experience, associated with creativity and peace? Or does solitude mean loneliness and isolation?

Scientists from the Northeastern Research Station found that positive experiences of solitude most often happened in natural, outdoor settings, whereas almost 80 percent of negative solitude experiences happened at home. Elderly people, poor rural women, and newcomers to a community are most susceptible to these negative experiences, which most often occurred at night and while the study participants watched television, read, or surfed the Internet.

Participants spent time daydreaming and reflecting during positive solitude experiences. Women were more likely than men to feel sad or stressed before their



Tom Iraci

When people go out into the wilderness, what keeps them from doing things that harm the landscape, pollute the water, and harass the wildlife?

solitude experience and to report fear as the reason for their negative feelings. Women's solitude experiences occurred more frequently at home, whereas men's experiences occurred outdoors, perhaps because men tended to feel more independent than did women prior to their experiences.

Partner: University of Massachusetts.

Lead: Northeastern Research Station.

Assessing the Environmental Impacts of Recreation

When people go out into the wilderness, what keeps them from doing things that harm the landscape, pollute the water, and harass the wildlife? What management strategies encourage better compliance with "leave-no-trace" guidelines? What educational programs are best in helping visitors understand that careless recreation can leave a lasting mark on the land?

These are a few of the questions that scientists at the Aldo Leopold Wilderness Research Institute in Missoula, MT, are grappling with as they develop, synthesize, and organize knowledge about the environmental impacts of human recreation into a coherent discipline of recreation ecology. Prior to their work, knowledge about recreation impacts was scattered and unorganized.

These scientists have gone beyond the conventional mail-back user survey to develop new research methods that have become the international standard. A number of fundamental principles have emerged from their work, and certain factors have been identified that influence the magnitude of environmental impact from recreation.

For example, to comply with "low-impact" practices, a visitor needs not only knowledge of the rules, but also a motivation to comply, an understanding of what constitutes compliance, and the capability to follow through with the appropriate behavior. Researchers are working to conceptualize the process that leads to compliance (or lack of it), and to use that information to educate visitors more effectively. Station research is thus providing much of the theoretical and conceptual foundation both for the field of recreation ecology and for managing recreation impacts. It has substantially influenced park and wilderness management around the world.



Tom Iraci

Station scientists receive many invitations to address national and international meetings and conduct workshops. Their knowledge syntheses and textbooks are used nationally and internationally by managers, scientists, and teachers. Find out more about studies at the Aldo Leopold Wilderness Research Institute by visiting <http://leopold.wilderness.net/>.

Partners: Montana State University, Southern Illinois University, University of Arizona, Virginia Polytechnic Institute and State University (Virginia Tech).

Lead: Rocky Mountain Research Station.



Providing a Snapshot of Conditions on Recreational Lands

How much forested recreation land is available in the United States? What do people most value about their forests? The *National Report on Sustainable Forests—2003* provides some answers. The report covers the general condition of U.S. forests in light of criteria and indicators identified in the international Montreal Process.

For the part of the report pertaining to forest recreation, indicators included amount of forest land available, number of forest-based recreation facilities, and degree of use of forests for recreation. Social-values indicators include the area of land managed to protect noncommodity values and the social, cultural, and spiritual values of forest lands.

The report reveals that about 81.8 percent of the total U.S. forest area, 610.7 million acres, is available for outdoor recreation—about 2.17 acres per person. In the drier, less forested Rocky Mountain/Great Plains Region, roughly 20 percent of camping facilities are associated with forested settings, whereas 40 to 50 percent of camping facilities in the Pacific Coast Region are forested. The Pacific Coast Region has the most areas with hiking facilities, closely followed by the Rocky Mountain/Great Plains, South, and East.

Researchers and managers have worked with the mountain-bike community to minimize conflicts between ongoing research activities and recreational uses.

The number of areas with picnicking facilities ranges from 98 in the South to 125 in the Rocky Mountain/Great Plains Region. Eastern owners of private forest provide many more miles of maintained trails (85 percent of the national total) than do private forest landowners in other regions.

Most respondents identified clean air and water as the most important values of forests, ranking these above scenic beauty, heritage, and wood products. A significantly smaller percentage of respondents chose clean air and water as the most important value of privately managed forests.

Partners: State University of New York, University of Georgia, University of Tennessee.

Lead: Southern Research Station.

Sharing Trails With Mountain Bikers

Although the primary mission of Bent Creek Experimental Forest in North Carolina is to conduct long-term forest research and demonstration, managers believe that, with careful planning and management, the area can provide limited but outstanding recreational



Work with local mountain bike community results in agreement on trails in Bent Creek Experimental Forest.

opportunities. Researchers and managers have worked with the mountain-bike community to minimize conflicts between ongoing research activities and recreational uses.

Over the past several years, mountain bikers created unauthorized trails at Bent Creek that interfered with research activities. When managers investigated, many trail users told them that it was difficult for them to know which trails were legally open to mountain bikes. In response, managers are making the requirements clearer by physically closing off the unauthorized trails, putting up information signs at trailheads, and clearly marking trails that are officially open for mountain bike or horse use. They have published a new trails map to make it easier for visitors to know which trails are open. For their part, volunteer bikers are helping maintain the area's trail system.

Lead: Southern Research Station.

Water and Air



Tom Iraci

Promoting clean water, reliable water supplies, and functioning aquatic and riparian ecosystems is an essential goal of land management. Riparian areas link the land surface with aquatic ecosystems and function as habitat for many plant and animal species. Watershed research provides scientific guidance for managers and policymakers in protecting and restoring watershed values such as water quantity and quality, riparian ecosystems, and aquatic habitats. The need for scientific studies on water is particularly pressing

today because of the urgency to develop new management techniques to address emerging mandates such as the Healthy Forests Initiative.

Air research helps managers and policymakers understand fire weather, air quality, smoke behavior, and climatic variability. Basic and applied research on fire meteorology and its influence on fire management has led to such helpful technologies as real-time remote sensing, ground observation networks, and seasonal and yearly predictive simulations. Such research and technology are critical for compliance with Clean Air Act Class I provisions, which require maintaining the quality of air in wilderness areas.

Altering Land Use to Clear the Water

Land uses in the Midwest are creating major stresses on coastal and riverine ecosystems. Excessive nutrient loads carried by the Mississippi River are causing an area of oxygen-depleted water in the Gulf of Mexico. Solutions will be complex, engaging the ecological, social, and economic forces that shape the communities and the landscape.

North Central Research Station scientists are collaborating with Federal, State, and local agencies and



universities in the Midwest to discover and implement changes in land use that benefit water quality. In 2004, they took the following actions:

- ▶ Worked with Iowa State University to determine where and how strategic increases in perennial vegetation can improve downstream water quality by limiting nutrient runoff to streams.

- ▶ Created an interactive program that enables regional stakeholders to evaluate the tradeoffs among ecological health, social resiliency, and economic productivity for alternative land uses within individual watersheds.
- ▶ Developed recommendations for riparian corridor and buffer strip widths that are used as guiding policy for incentive programs for private lands, as well as to provide information for larger strategies that maintain and manage forested riparian and wetland areas. Planners in Minnesota's largest county are using these recommendations to draft new planning regulations.

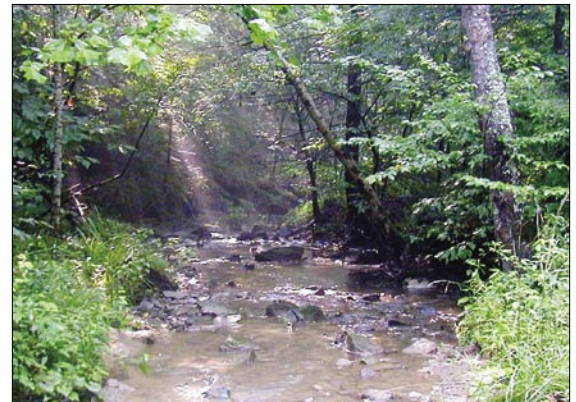
Implementation of these research results will improve water quality and the quality of life for both streamside and downstream communities.

Partners: Iowa State University, University of Illinois at Urbana-Champaign.

Lead: North Central Research Station.

Tracking Improvements in Watershed Functions

Managers need a way to monitor the performance of their strategies for protecting and restoring aquatic ecosystems. Pacific Northwest Research Station scientists developed an effectiveness monitoring plan to evaluate the Northwest Forest Plan's (NWFP) aquatic conservation strategy. The strategy is directed at protecting good habitat and healthy fish populations, and has the long-term objective of restoring degraded ecosystems. The effectiveness monitoring plan measures success by counting the number of watersheds that are improving in ecological integrity, as evaluated by improvements in an array of indicators.



The monitoring plan is built on a knowledge-based Ecosystem Management Decision-Support (EMDS) system. It incorporates expert knowledge and numerical data into a GIS. It shows how the field indicators are evaluated and provides consistent interpretation of data in a clear framework. The model's rule sets and reference values are adjusted by teams of local experts to fit the ecological provinces in the planning area. Over time, further adjustments are possible; thus, the model's analysis procedures can be revised as new science becomes available.

In addition to supporting the NWFP's conservation strategy, EMDS system

has been used for analysis in the North Coast Watershed Assessment in northern California. It also is being used by several national forests and is being considered for use by resource scientists and managers in Taiwan and China.

Partners: Chinese Academy of Forestry; DOC NOAA; DOI BLM; National Taiwan University; USDA Forest Service—Pacific Southwest and Pacific Northwest Regions, Natural Resource Information System (Washington Office [WO]), Ecosystem Management Coordination Staff (WO), Kootenai National Forest, Idaho Panhandle National Forest; Oregon State University; EPA.

Lead: Pacific Northwest Research Station.

Restoring Watersheds: Lessons From the Great Basin

Streams and riparian areas in the semi-arid Great Basin are often severely degraded, compromising their ability to supply water and support regional biodiversity. A collaborative ecosystem management project initiated by the Rocky Mountain Research Station's Reno Laboratory and the Humboldt-Toiyabe National Forest in Nevada is improving understanding of the processes that influence these systems and contributing to methods for maintaining and restoring ecosystem sustainability.



Tom Iraci

The effects of both climate change and human-caused disturbance on linkages among landforms, water, and vegetation are being examined in several study watersheds. Island Press published initial results in March 2004 in a book titled *Great Basin Riparian Ecosystems: Ecology, Management and Restoration*. The book synthesizes existing knowledge of the geomorphic history, sensitivity to



disturbance, geomorphic and hydrologic processes, water quality, and vegetation dynamics for the study watersheds and surrounding region. The book details implications for restoring and managing streams and riparian areas and gives specific process-based restoration approaches. These include such tools as (1) a categorization of basin sensitivity to natural and human-caused disturbances and management and restoration implications for different basin types; (2) a model of the recovery thresholds of dominant meadow ecosystems, along with management and restoration implications; and (3) an approach for using “restoration experiments” to define the recovery potentials of riparian meadow ecosystems.

The interdisciplinary and multiscale approach taken in this project serves as a model for conducting similar watershed programs, and the process-based information linking climate history, geology, hydrology, and ecology has broad-scale implications for managing watersheds and riparian ecosystems.

Partners: EPA; Lafayette College; Stanford University, USDA Agricultural Research Service; University of Nevada—Reno; USDA Forest Service—NFS, Stream Systems Technology Center; Western Carolina University.

Lead: Rocky Mountain Research Station.

Predicting Smoke Drift, Preventing Traffic Hazards

When a fire burns, it is difficult to determine where the smoke will likely go. The South Carolina Forestry Commission has implemented PB-Piedmont, a real-time tool to help South Carolina forest managers figure out where postburn smoke is likely to go and whether it will present hazards to transportation. The model is particularly useful for predicting the movement of smoke over complex terrain such as the Piedmont.

PB-Piedmont is connected with predicted and hourly weather data through the Southern High-Resolution Modeling Consortium and the Georgia Forestry Commission. This linking of smoke patterns with weather conditions enables land managers to determine precisely where postburn smoke is likely to go. In addition, PB-Piedmont is an educational tool that can help land managers understand the complex coupling between large-scale wind systems and the smaller scale wind patterns unique to the watersheds surrounding their lands.

Partners: Georgia Forestry Commission, South Carolina Forestry Commission, Southern High-Resolution Modeling Consortium.

Lead: Southern Research Station.

Designing Optimal Buffer Strips

Society is demanding assurances that water quality will not be degraded by silviculture and related operations. Streamside management zones (SMZs) are buffer strips of vegetation adjacent to intermittent or perennial streams, lakes, or other bodies of water. Used to protect streams from nonpoint-source pollution resulting from logging operations, they are a cornerstone of best management practices (BMPs) in forestry.

The width and harvest intensity of SMZs that best balances protection of water quality with commercially valuable timber harvesting has not been determined. Moreover, although BMPs have been shown to protect water quality, their use is voluntary and inconsistent across most jurisdictions. Considering that data on their effectiveness is sparse and frequently inconclusive, it seems likely that BMPs alone will not provide the assurances demanded by regulators.



The Southern Research Station is comparing SMZs and watersheds in the southern Appalachian region before and after harvest under different SMZ widths and harvesting intensities. Baseline characteristics of several watershed SMZs have been determined preharvest, and researchers are predicting how silvicultural treatments will affect the future stands.

This research will provide defensible scientific guidance on the optimal design of SMZs in Appalachian riparian hardwood forests. State and Federal agencies and

owners and managers of forested lands will benefit greatly from better knowledge of effective SMZ design.

Partners: MeadWestvaco Corp., National Council on Air and Stream Improvement, Virginia Tech.

Lead: Southern Research Station.

Restoring Degraded Streambanks in Southern Appalachia

Riparian zones along many rivers and streams in the southern Appalachians have been severely degraded by poor land use practices. Some of these streams have undergone restoration activities intended to stabilize streambanks and encourage the regrowth of trees and herbaceous groundcover in the riparian zone. Researchers at the Coweeta Hydrologic Laboratory are studying these streams and discovering much about how riparian zones in the southern Appalachians recover structure and function after being treated.

Restoration markedly decreased the movement of nutrients and sediments through the riparian zones of these streams. For example, 2 years after restoration activities took place, nitrate-nitrogen levels in the soil were decreased from 1.1 milligrams per liter to 0.01 milligrams per liter. Restored streamside areas showed improved vegetation uptake, improved infiltration and soil retention, and increased microbial activity. Restoration activities also increased the stability of streambanks, both by the addition of physical structures (revetments) to hold the banks in place and by encouraging regrowth of new root systems in the riparian zone. Research results have been widely used by local, State, and Federal agencies to increase restoration activities in the southern Appalachian region.

Partners: University of Missouri, USDA Forest Service—NFS.

Lead: Southern Research Station.



Predicting Impacts on Water Quality in Puerto Rico

What are the most important factors governing water quality in a watershed? Scientists from two universities and the U.S. Geological Survey (USGS) used multivariate statistics and GISs to predict certain water-quality conditions in unmonitored watersheds in Puerto Rico. Then, they analyzed long-term water data collected by the USDA Forest Service and the USGS to characterize the water quality of 15 watersheds on the island.

Through statistical analysis of the data and of environmental variables, the researchers found that the most important factors affecting water quality were changes in forest cover, percentage of limestone, mean annual rainfall, and shape of the watershed. They also found that the water that flows from USDA Forest Service lands was of high quality.

Equations developed in this study provide an objective way to identify and locate projects in watersheds where water quality is at lowest risk from changes in forest cover, land use, or management practices. In 2003, findings were published and are being used by natural resource managers in Puerto Rico to assess the potential impacts of proposed projects.

Partners: University of Connecticut; University of Pennsylvania; USGS, Water Resources Division, San Juan, Puerto Rico.

Lead: International Institute of Tropical Forestry.

Resource Data and Analysis



Accurate and dependable tools for gathering and analyzing information about the land are essential for effective management. USDA Forest Service R&D provides inventory, assessment, quantitative analysis, and technique-development services through its Resource Data and Analysis Programs. Our tools help managers assess the

condition of ecosystems and opportunities for restoration, conduct risk assessments for fire and invasive species, prioritize allocation of management resources, and measure the effects of various forms of fragmentation on the viability of forest ecosystems.

Research products we have developed include the following:

- ▶ *Spatial analysis tools used in integrated remote sensing and to collect land-based resource data for maps used to analyze land cover and risk from various disturbances.*
- ▶ *Integrated databases and Web tools that improve methods for data management and distribution.*
- ▶ *Better models to predict climate change and spread of invasive species.*

Our goal is to provide methods, tools, and information to landowners, land managers, policymakers, and other interest groups so they can make informed and scientifically sound decisions about land use, management, and policy.

Through enhanced access to this vital information, individual landowners will derive more profit from their forest investments, and forest industry will be more competitive.

Providing Rapid Information Delivery for Forest Managers

State foresters, timber industry managers, and land planners depend on the USDA Forest Service's Forest Inventory and Analysis (FIA) data for accurate information about the status and trends of the Nation's forests. To be useful, this information must be both timely and convenient for users to access.

In 2004, FIA staff launched the following tools to enhance delivery of FIA data and analysis products to users:

- ▶ The Spatial Resources Support System, a simple, spatial analysis system that permits decisionmakers to design alternatives by using real

data and then display the results in tabular and graphical format.

- ▶ A new Web-based program that enables mill managers contributing data to the North Central Station timber product output survey to enter, edit, process, and retrieve their own mill data.
- ▶ Regional Spatial Data Services centers to give external users access to detailed plot coordinates of forest lands minus information about the actual locations of these lands (because disclosing the actual locations would violate the Privacy Law).
- ▶ A new North Central Station FIA Web site portraying both regional and national activities.

These new tools allow public and private landowners to base their planning and decisionmaking on the best available forest information, enabling them to make better-informed choices about the future of the natural resources under their stewardship. Through enhanced access to this vital information, individual landowners will derive more profit from their forest investments, and forest industry will be more competitive.

Partners: *USDA Forest Service—Pacific Northwest Research Station, State and Private Forestry; State Foresters.*

Lead: *North Central Research Station.*

Characterizing America's Family Forest Owners

Results of a nationwide survey by the Northeastern Research Station show family forest owners now control almost half the Nation's forest land, or about 262 million acres. And their numbers are growing—in the past 10 years, the number of family forest owners rose 11 percent, from 9.3 million to 10.3 million.

Family forests are lands at least an acre in size and owned by individuals, families, and others who are not incorporated as a business. In the National Woodland Owner Survey, researchers at the Northeastern Research Station queried almost 7,000 family forest owners to see why they own the land and what they intend to do with it.

Most family forest owners live in the Eastern United States and are more highly educated than the general population. Seven of 10 live on or within a mile of their forest land. Most own their land to enjoy the beauty of scenery, to protect nature and biological diversity, for privacy, or to pass the land on to their heirs.

These landowners are aging. The average family forest owner is 60, and 19 percent of family forest land is owned by people over 75. As (family forest) landowners

As [family forest] landowners age, their properties are more likely to be sold or transferred to new ownership. It's likely that land transfers will be substantial during the next 10 to 20 years.

age, their properties are more likely to be sold or transferred to new ownership.

It's likely that land transfers will be substantial during the next 10 to 20 years. The transfer to the next generation could result in minimal or dramatic land changes, depending on the personal goals of the new owners. Will they keep it for aesthetic reasons, as a family legacy, or to protect nature? Or will the land be parceled and sold for development? The fate of much of the Nation's forest land lies in the hands of these family foresters.

Lead: *Northeastern Research Station.*

Projecting Urban Growth

Over the next 25 years, the amount of urban and developed land in the United States is projected to increase by 79 percent, and much of the growth will occur in already stressed areas. A Pacific Northwest Research Station study detailed these findings by using historical data and socioeconomic factors to project



Bob Szaro

potential future urbanization and development.

Urban and developed land now covers 5.2 percent of the land base in the 48 contiguous States. It is projected to expand to cover 9.2 percent of the land base in the next 25 years. Much of the growth will happen in areas where the environment is already relatively stressed by human interactions, such as some coastal counties.

Expanded urban growth has potential impacts on sensitive watersheds, riparian areas, wildlife habitat, and water supplies. Direct impacts include the conversion of forest land, which can increase the size of the WUI and heighten the risk of wildfire to people and structures, as well as reduce quality of wildlife habitat and areas for outdoor recreation. Indirect impacts include forest fragmentation, which could adversely affect wildlife habitat and green space.

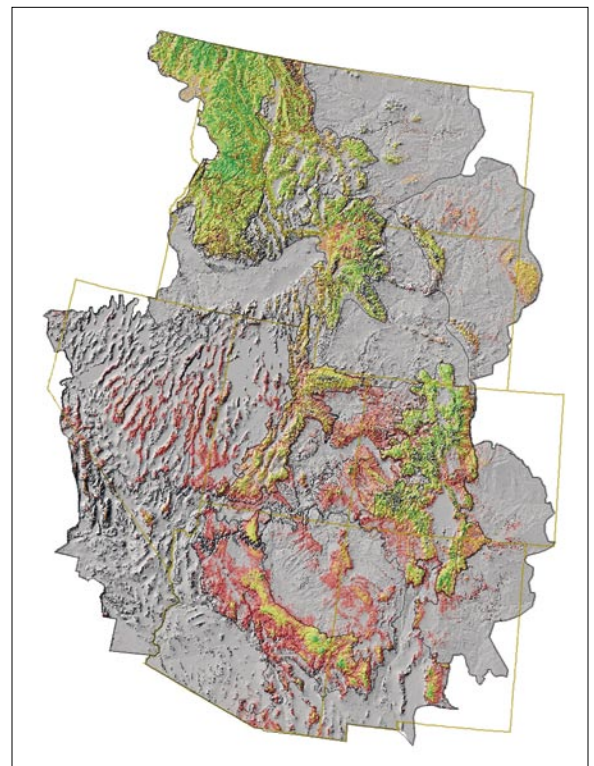
These findings have implications for landscape and urban planning. They will also be useful in the large-scale analyses being conducted by the USDA Forest Service on changes in forest biodiversity and by the EPA on global climate change and the amount of carbon stored in forests.

Partners: *EPA; Oregon State University, Agricultural and Resource Economics Department; USDA Natural Resources Conservation Service.*

Lead: *Pacific Northwest Research Station.*

Using FIA Data at a Regional Scale

FIA data have historically been used to perform analyses pertinent to large geographic areas. In 2004, Rocky Mountain Research Station scientists collaborated with the Remote Sensing Applications Center in Salt Lake City, UT, to start making this extensive forest resource information available at a regional scale. Their goal is to produce maps of forest characteristics that are suitable for more detailed regional land management and context-based assessments.



Forest biomass map derived from MODIS imagery.

The researchers used Moderate Resolution Imaging Spectroradiometer, also called MODIS (an instrument aboard the National Aeronautics and Space Administration's satellite used to view the Earth), imagery and many geospatial data layers to develop the first nationwide map of forest biomass at a moderate resolution.

Forest managers will be able to use the map to do assessments at a regional scale, such as making an inventory of habitat

for selected wildlife, documenting the loss of forest resources to fire, evaluating forest fragmentation and urbanization, identifying land suitable for timber production, and locating areas at high risk for invasion by insects or diseases. The map is currently under review and is planned for public release.

Partner: USDA Forest Service—Remote Sensing Applications Center.

Lead: Rocky Mountain Research Station.

Rapid development (in Puerto Rico), with its attendant sprawl and degradation of natural resources, worries environmental groups, researchers, government agencies, and citizens. They are concerned about maintaining the extent and health of forests, wetlands, and farmlands, and the abundance and quality of drinking water.

Assessing Urbanization in Puerto Rico

On the rapidly urbanizing island of Puerto Rico, more than 4 million people live within 3,475 square miles. The amount of urban and developed land has increased by 7.2 percent in the last decade and now amounts to 11 percent of the island's acreage.

This rapid development, with its attendant sprawl and degradation of natural resources, worries environmental groups, researchers, government agencies, and citizens. They are concerned about maintaining the extent and health of forests, wetlands, and farmlands, and the abundance and quality of drinking water.

Researchers at the International Institute of Tropical Forestry Geographical Information System and Remote Sensing Laboratory have developed an island-wide study of the urban and developed areas of Puerto Rico. Researchers integrate remote-sensing technology and census information to analyze how people are distributed on the land, the relationship of population density to density of urban cover, and land consumption and urban sprawl.

The resulting maps and assessments will be useful for land use planning and resource protection, and the methodology and findings will guide similar assessments in other areas.

Partners: Puerto Rico Department of Natural and Environmental Resources; Puerto Rico Gap Analysis Project; USDA Forest Service—International Institute of Tropical Forestry; USGS—Biological Resources Division, North Carolina Cooperative Research Unit.

Lead: International Institute of Tropical Forestry.

Assessing Biodiversity in Puerto Rico's Mature-Forest Communities

The most prevalent forest cover on Puerto Rico is secondary forests regenerating on abandoned agricultural land. These newly emerging forests, which contain a mix of native and exotic plants, are coming up alongside remnants of mature forest communities that remain dominated by native species. The mature-forest

communities serve as reservoirs of native biodiversity.

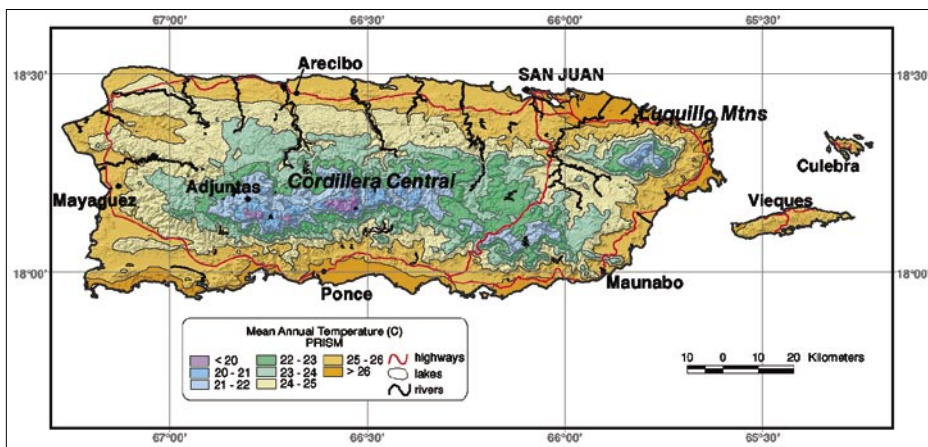
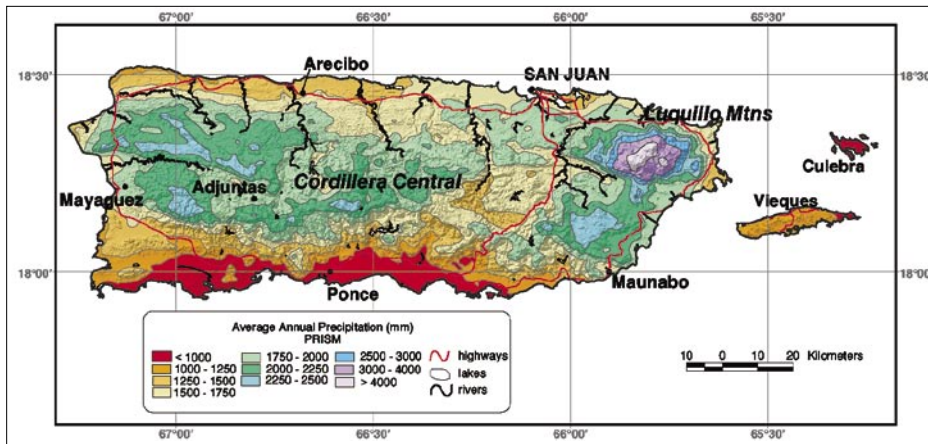
Researchers looked at the composition and conservation status of species in mature-forest communities within eight forest types occurring along an elevational gradient in Puerto Rico. Plots were located in a wide range of landscapes—from large tracts of protected mountain reserves to small fragments in heavily developed lowland areas.

Researchers found 348 plant species within 9 replicates of 33- by 33-foot plots in each forest type. By far the majority of these species—93 percent—are native, and 13 percent of those are endemic to the island. The percentage of native and endemic species was lowest in the most disturbed lowland landscapes, but all community types showed a high percentage of native species. Forest types and representative communities include Elfin Woodland, Sierra Palm, Palo Colorado, Tabonuco, Lowland Moist, Dry, and Mangrove. This information will be useful for land management, restoration, and conservation purposes.

Partner: Puerto Rico Gap Analysis Project.

Lead: International Institute of Tropical Forestry.





Creating Digital Climate Maps for Puerto Rico, Vieques, and Culebra

Researchers generated digital climate maps for the first time for the Caribbean islands of Puerto Rico, Vieques, and Culebra with a model called Parameter-Elevation Regressions on Independent Slopes. The model uses spatial data sets, a database, and expert interaction to generate grids of climate variables from climate station data. The data are compatible with geographic information systems.

Such maps are important for spatial analyses related to watershed management, for mapping vegetation type with satellite imagery, for mapping present and hypothetical future ecological zones, for modeling biophysical processes such as carbon and nitrogen fluxes, and for predicting species and habitat distributions.

This model generated maps of mean monthly and annual precipitation and minimum and maximum temperature for the islands over the 1963–95 averaging period. Released in late 2003, these data were critical in 2004 in generating the first map of forest biomass in Puerto Rico for a national forest biomass map from USDA Forest Service forest inventory data. In 2005, the Natural Resources Conservation Service, National Hurricane Center, and National Weather Service all began using the data to predict precise spatial patterning of weather and extreme events.

Partners: Oregon State University, Spatial Climate Analysis Service.

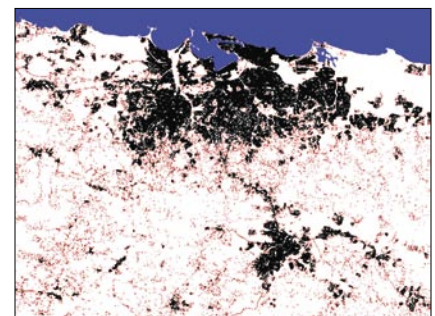
Lead: International Institute of Tropical Forestry.

Providing a Quick Snapshot Through the Clouds

Persistent cloud cover over many regions complicates remote sensing with optical satellite imagery. Useful analysis of vegetation maps compiled from remotely sensed images may require that much of each captured image be free of clouds.

Researchers used a novel approach to develop two relatively cloud-free Landsat image mosaics over Puerto Rico and the islands of Vieques and Culebra, one each for 1991 and 2000, from 20 different dates of imagery. The two mosaics enabled researchers to detect rapid urban change by using only spectral data and the simplest of image-classification techniques.

The new methodology provided a first and vital estimate of land development on the islands over the decade. The image mosaics showed that between 1991 and 2000, Vieques and Culebra experienced a remarkable 49-percent increase in patches of urban and built-up lands of less than 2.5 acres. The resulting map shows a continuing pattern of rapid urbanization of remaining undeveloped patches



of land, including forests, in largely urban areas. Unprotected forests in and near metropolitan areas will likely continue to be developed more rapidly than land in other areas, as earlier studies had shown.

Partners: USDA Forest Service—Remote Sensing Applications Center.

Lead: International Institute of Tropical Forestry.

Wildlife and Fish



Wildlife and fish are not only sensitive indicators of ecosystem health, but they are highly visible to the public, and their welfare is a key environmental issue. The healthy habitats, populations, and biodiversity required in laws such as the Endangered Species Act and the Clean Water Act are key strategic goals for USDA Forest Service management.

The primary wildlife research emphasis is on birds, especially marbled murrelets and spotted owls. The program is focused on protecting or enhancing wildlife within the context of management activities and other habitat change. Research projects address disturbance from forest thinning and silviculture, habitat fragmentation, fire, urbanization, roads, recreation, invasive plants, and global climate change.

Research on threatened and endangered species accounts for about a quarter of the wildlife research budget. Landscape-scale modeling and GIS techniques have helped to define key habitat types and areas for species of concern. An increased emphasis on the design of broad-scale monitoring is coordinated with the national forests to address forest planning needs.

National forests and grasslands cover a wide diversity of aquatic ecosystems. They encompass about 128,000 miles of streams; 2.2 million acres of lakes, ponds, and reservoirs; and 16,500 miles of coastline. The fisheries research program develops information to maintain habitat, populations, and species diversity, including species and stocks at risk, and supports meeting legal requirements and management objectives of the USDA Forest Service.

The national forests support more than 50 percent of the remaining habitat for natural populations of important fishes, mussels, and crustaceans. National programs such as "Rise to the Future," "National Recreation Fishing Policy," and "Bring Back the Natives" have created emphasis areas that commit the USDA Forest Service to scientific excellence in fisheries and fish habitat management.

The chestnut-sided warbler may be the new "canary in the coal mine," signaling a warning about fragmentation of habitat.

Assessing Breeding Success: Some Birds Do Not Like the "Burbs"

The chestnut-sided warbler may be the new "canary in the coal mine," signaling a warning about fragmentation of habitat. In the Northeast, as land development breaks up habitat features across large landscapes, scientists are concerned about the effect of this fragmentation on the breeding success of birds and other animals. A Northeastern Research Station

scientist found that the warbler breeds better in larger patches of unbroken meadowland.

Breeding success was studied on patches of land that ranged from 0.75 to 1.75 acres in meadowlands where forest trees and shrubs had been growing for 4 or 5 years—making them actually early-successional forests. Large patches were the top choice of breeding warblers—nests were started earlier and density was

greater. The late nest-building found in the smaller patches suggests a lower-quality habitat.

The exact patch sizes most birds need to breed is unknown, but this research shows that, for chestnut-sided warblers and other early-successional bird species, large swaths of regenerating forest lands are critical to their breeding success.

Lead: Northeastern Research Station.



Determining the Declining Population of the Northern Spotted Owl

Pacific Northwest Research Station scientists summarized data from 14 long-term demography studies on the northern spotted owl in Oregon, Washington, and California during the period 1985–2003. They found that, although the population in four areas is stable, the spotted owl population in eight areas is declining, and the population in a ninth area is probably declining. One area had insufficient data to estimate whether population growth was increasing or declining.

The estimated average rate of decline on eight federally managed areas was 2.5 percent a year, compared to 6.6 percent a

Scientists also believe the decline in spotted owl populations may be caused by competition with barred owls, a more aggressive species.

year on the other study areas (private, tribal, and State forest lands). Population declines were greatest in the State of Washington.

Population declines are likely the result of a number of factors, including loss of habitat on non-Federal lands, competition from barred owls, and loss of habitat from fire and parasitism. Scientists also believe the decline in spotted owl populations may be caused by competition with barred owls, a more aggressive species. As part of their analysis of this hypothesis, scientists completed genetic studies of hybridization between spotted and barred owls.

These findings, which are the result of a 10-year review on the status and trends of the spotted owl, are used by Federal agencies to determine the status of the northern spotted owl and to evaluate factors that influence the owl population.

Partners: Colorado State University; DOI BLM, NPS; Hoopa Tribal Forestry; National Council for Air and Stream Improvement; Oregon State University; Simon Fraser University; University of Minnesota; USGS.

Lead: Pacific Northwest Research Station.

Managing Fisher Habitat and Fuels Treatment



The fisher, a small, mink-like forest-dwelling animal, is one of California's greatest land management challenges. How are managers to balance the habitat needs of fishers—forest areas with dense cover, large snags, and live trees—with the need to treat fuels to reduce risk of crown fires? A significant collection of fisher-related research released in FY 2004

provided greatly improved information on which to base decisions affecting the ecology and management of this reclusive animal.



Newly released papers include information on the fisher's preferred habitat conditions, home range characteristics, diets, genetic composition, biology, ecology, and distribution. This new information has been instrumental in guiding policy and will be an important source of information for land managers who face new questions about the impacts of human activities on fishers.

The need for new information on fishers was precipitated by the recent finding by the USFWS that Federal listing of the fisher was "warranted but precluded."

Partners: California Department of Fish and Game; USDA Forest Service—Pacific Southwest Region; USFWS; several non-governmental organizations.

Lead: Pacific Southwest Research Station.

Using Prescribed Fire To Restore Habitat in Ponderosa Pine Forests

Scientists with the Rocky Mountain Research Station are cooperating with colleagues from universities, agencies, and conservation groups to characterize bird community response (particularly that of cavity-nesting species dependent on fire-maintained habitats) in eight Western States to changes in the forest that follow both prescribed fire and other fuel-reduction treatments.

After collecting 2 years of pretreatment data, researchers treated nearly 9,000 acres at eight locations with prescribed fire and thinning during the autumn of 2003 and spring of 2004. Treated lands included certain forests managed by The Nature Conservancy and the Fremont National Forest in Oregon and parts of the Okanogan (Washington), Payette (Idaho), Coconino (Arizona), Kaibab (Arizona), Apache-Sitgreaves (Arizona and New Mexico), and Gila (New Mexico) National Forests. Scientists used standardized protocols to quantify the severity of the burn, the amount of fuels, wildlife habitat, and bird populations.

Findings are providing consistent information on the effects of fuel reductions and burn severity on wildlife—key to understanding the ecological consequences of implementing the Healthy Forests Initiative and the National Fire Plan



throughout the interior West. For more information see <http://www.rmrs.nau.edu/lab/4251/birdsnburns/>.

Partners: Boise State University; Colorado State University; Idaho Department of Fish and Game; Montana State University; Northern Arizona University; South Dakota School of Mines and Technology; The Nature Conservancy of Oregon; University of Arizona; University of Idaho; University of Montana; USDA Forest Service—NFS.

Lead: Rocky Mountain Research Station.

Crayfish are ecological indicators and also are economically important as human food resources and as bait for recreational and commercial fisheries.

Assessing Risk for Crayfish and Other Aquatic Creatures

To conserve wildlife populations in the context of human population growth and changing land use practices, land managers need to be able to determine which populations are most at risk over large geographic areas. These risk assessments are important tools in the planning and priority setting on lands in the NFS. For example, NFS lands in the Eastern United States have become increasingly important for the protection, restoration, and enhancement of aquatic resources such as crayfish, which are ecological indicators and also are economically important as human food resources and as bait for recreational and commercial fisheries.

The Eastern United States has the most diverse crayfish populations in the world, and NFS lands are key strongholds for crayfish biodiversity. The role of crayfish as an ecological indicator, however, is currently not fulfilling its potential in managing NFS lands because data on population distributions are not being used effectively.

Scientists in Blacksburg, VA, developed a watershed-based risk assessment for crayfish including 254 crayfish taxa on 991 fifth-level watersheds. On average, each watershed had 5.3 taxa (range: 1–21). One watershed alone had 27 taxa.

The researchers determined that southern Appalachian watersheds and several watersheds in Ohio, Illinois, Indiana, and Missouri were at the highest risk. Managers can use the technique and specific results to protect not only threatened

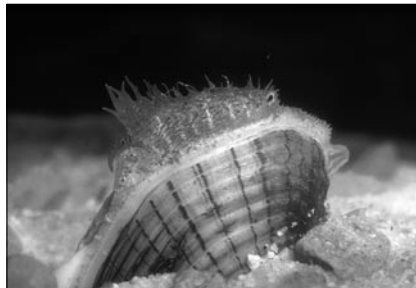
crayfish but also other potentially imperiled aquatic organisms.

Partners: James Madison University; USDA Forest Service—NFS.

Lead: Southern Research Station.

Developing Faster and Better Surveys of Freshwater Mussel Populations

Freshwater mussels are one of the most endangered groups of animals in the country. The mussel fauna of the Eastern United States is the most diverse on Earth and plays a crucial role in maintenance of water quality and overall



Freshwater mussels are one of the most endangered groups of animals in the country. National forests, particularly in the Southern Region, are among the most important areas for conservation of this imperiled resource.

integrity of stream ecosystems. National forests, particularly in the Southern Region, are among the most important areas for conservation of this imperiled resource.

National forest managers and other natural resource professionals need tested, repeatable, and practical field methods to monitor mussel populations and assess their viability. Previous methods used

for inventory and monitoring of mussel populations often yielded unsatisfactory results—they were statistically imprecise, not easily comparable with data obtained by other methods, limited to a single stream site, or impractical to apply routinely and in a variety of settings.

The Southern Research Station has developed and tested survey methods that largely solve these longstanding problems. Because they are designed to produce precise, repeatable estimates of population size and to concentrate the sampling effort in areas likely to harbor mussels, these methods can effectively sample as much as 7.5 miles of stream in about 5 days. They have been successfully applied in the Talladega National Forest, AL, and the Daniel Boone National Forest, KY, to estimate population size of four threatened and endangered mussel species, as well as other co-occurring species.

These studies are the first to provide precise estimates of total population size of mussels in entire watersheds. Such estimates are of vital importance in assessing the viability of imperiled mussel populations. These methods provide an important new, science-based tool for

natural resource professionals to monitor and assess the status of mussel populations and to evaluate the effectiveness of management designed to conserve these imperiled animals.

Partners: Alabama Forestry Commission, Eastern Kentucky University, Kentucky Division of Water, Kentucky State Nature Preserves Commission, The Nature Conservancy, USDA Forest Service—NFS, USFWS.

Lead: Southern Research Station.

Offering a Rich Research Tool: Summary of Parrot Data

A new summary of 27 years (1972–2000) of nest histories of the endangered Puerto Rican parrot in the Luquillo Experimental Forest offers a comprehensive basis for scientists to analyze factors that influence the survival of this endangered bird. Published in FY 2004, the work summarizes nesting data for each nest and pair, including number of eggs produced, fertility and hatchability of eggs, how many nestlings fledged, and how many hatchlings died and why (predation or parasitism). The summary also notes when eggs or nestlings were fostered into the nest from an aviary or out of the nest to the aviary.

The summary provides the basis for analyzing trends in parrot nesting productivity, fertility, egg hatchability, predation, parasitism, nest success, and annual survival of breeding parrots. These data will be available for analysis by scientists concerned with emerging trends in nest productivity and survival. They are currently being used to model the parrot population to identify factors hindering the parrot's recovery.

Partner: USFWS.

Lead: International Institute of Tropical Forestry.



Jerry Bauer

Nesting pair of Puerto Rican parrots (Amazona vittata).

Renewable Resource Management and Use and Resource Extraction



This research program provides scientific, management, and technology services to forest and rangeland owners, managers, policymakers, scientists, and the public. It has three main emphases: (1) furthering understanding of the structures and processes of forest and range ecosystems, (2) developing effective and environmentally sound technologies for managing forests and rangelands, and (3) delivering the goods and services that people use and value from forests and rangelands.

An array of outputs includes basic knowledge, prediction, and decision models; databases; measurement techniques; analysis tools; new products and processes; and use technology. Our goal is to facilitate science-based management that sustains the ecological processes of forests and rangelands while enabling them to produce the goods and services society requires.

We mapped forest conditions in the Lakes States from the mid-1800s to the present and found that ...the region's forests have shifted away from conifers toward hardwoods as the dominant species.

Providing Tools for Managers in a Changing Landscape

Population growth, land ownership trends, and development patterns can have both positive and negative consequences for regional landscapes. Local decisionmakers need knowledge and tools to anticipate and respond to significant changes.

In 2004, the North Central Research Station developed the following tools and assessments to help community planners and resource managers understand and make decisions about landscape-related change:

- ▶ A comprehensive Web site describing the trends, intensity, and distribution of change across the Midwest landscape. This evolving tool pinpoints where and how land cover, forests, human demographics, and wildlife are being affected by change.

- ▶ Maps of forest conditions in the Lakes States from the mid-1800s to the present. The maps illustrate that as the region's forests have shifted away from conifers toward hardwoods as the dominant species, few opportunities exist to restore economically valuable conifers to dominance. Restoration efforts likely would be slow and expensive.

Documenting both local and widespread changes in forest conditions provides land managers with a sound basis for predicting how landscapes may change in the future. It also provides conservation and community planners with tools for sustaining essential ecosystem services, such as clean water, recreation, and harvestable forest products, when implementing conservation and land development projects.

Partners: Iowa State University, USDA Forest Service—Eastern Region.

Lead: North Central Research Station.

Fueling the Growth of Biomass Energy

Biomass offers America a tremendous opportunity to use domestic, sustainable resources to provide its power needs from plants and plant-derived materials. The USDA Forest Service and DOE have invested 30 years of cooperative research in developing the scientific knowledge and technology required to grow short-rotation woody crops, mostly hybrid poplar and willow, as biofuel and fiber feedstocks.



In 2004, North Central Research Station scientists provided technical and logistical support to two public utilities commissions in northern Minnesota to implement a large-scale biomass project that calls for using hybrid poplar as a renewable and sustainable supply of green energy. The project has the potential to provide 35 megawatts of renewable power, to bring more than \$700 million in gross revenues for 20 years to the cities of Hibbing and Virginia, MN, and to create more than 170 long-term jobs.

Use of hybrid poplar biomass for energy strengthens rural economies and decreases America's dependence on imported oil.

Acid rain leaches calcium from forest soils, and this research provides good evidence that acid rain lowers cold-tolerance, making red spruce more susceptible to winter injury.)

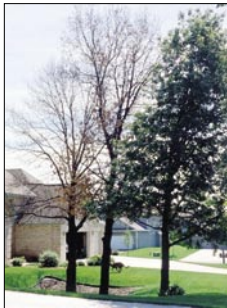
In addition, the growing of hybrid poplar uses less pesticide than many other crops, and thus contributes to reducing air and water pollution.

Partners: DOE—Oak Ridge National Laboratory, Iowa State University, Michigan State University, University of Minnesota, University of Wisconsin.

Lead: North Central Research Station.

Battling Oak Wilt Through Education

Oak wilt, a rapidly spreading fungal disease, kills thousands of red, bur, and white oaks in



forests, woodlots, and urban backyards each year. Oak wilt is present throughout much of the Eastern United States from Minnesota to Texas and east to the Carolinas. As communities expand into forested landscapes, oak forests and woodlands are at risk. More than 80 percent of the new outbreaks result from construction activities that wound oak trees.

North Central Research Station scientists developed an educational compact disk about the spread of oak wilt. This comprehensive reference provides practical guidance for homeowners, professional arborists, and foresters. It focuses on four critical topics: survey and inspection; prevention and treatment; education; and monitoring and evaluation. More than 8,000 copies were distributed in 2004.

Simple preventive measures in the spring and summer, such as protecting construction-site trees and learning when to prune oaks, can lead to positive results.

With this new science education tool, communities are better prepared to identify, prevent, and control oak wilt.

Partner: USDA Forest Service—Northeastern Area State and Private Forestry.

Lead: North Central Research Station.

Linking Acid Rain to Severe Winter Injury for Red Spruce

Following a wicked freeze in 2003, winter injury to red spruce trees from Maine to New York was higher than in any year on record. Injuries were more than five times higher than typical, and nearly three times higher than the highest injury measured in the past two decades.

At the Aspen Free-Air Carbon Dioxide Enrichment experiment in northern Wisconsin, trees being grown under elevated carbon dioxide and ozone conditions are providing a window on the future.

Scientists at the Northeastern Research Station analyzed patterns of injury and discovered that damage was greatest in areas that receive more acid rain. Acid rain leaches calcium from forest soils, and this research provides good evidence that acid rain lowers cold-tolerance, making red spruce more susceptible to winter injury.

Partner: University of Vermont.

Lead: Northeastern Research Station.

Providing a Window on Climate Change

Today's forests grow in a changing world. The global average temperature is expected to continue to increase through this century, triggered by increasing concentrations of carbon dioxide and other greenhouse gases in the atmosphere.

Global climate change, combined with air pollution, increased ultraviolet radiation, and intensified land use, will likely result in rapid ecosystem changes. Land managers and policymakers need a better understanding of the effects on forests from global climate change and how they can be mitigated.

At the Aspen Free-Air Carbon Dioxide Enrichment (FACE) experiment in northern Wisconsin, trees being grown under elevated carbon dioxide and ozone conditions are providing a window on the future. Published studies revealed that northern trees growing under high-ozone conditions store less carbon and do not grow as fast as trees growing in increased carbon dioxide alone. Another study suggests that increased cloudiness could reduce the growth increase normally expected with higher carbon dioxide levels.

Cumulatively, this work is clarifying the important role forests can play in mitigating atmospheric carbon dioxide increases and helping to identify the factors that may limit that ability.

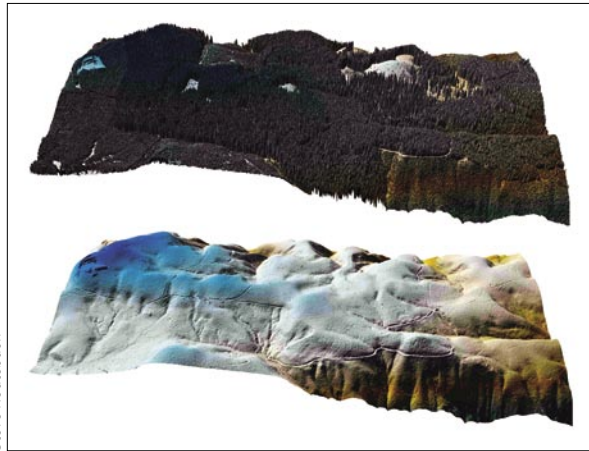
As the Aspen FACE results add to fundamental knowledge of ecosystem processes, this work can also help managers effectively project how forests are likely to grow in a future environment and to anticipate how they might modify their current management choices to adapt to changed conditions.

Partners: Brookhaven National Laboratory; Canadian Forest Service; DOE; Michigan Technological University; National Science Foundation; USDA Forest Service—North Central and Northeastern Research Stations, Global Change Program.

Lead: North Central Research Station.

Using LIDAR Remote Sensing to Accurately Measure Forest Canopies

Dependable field techniques have long existed for measuring ground fuels in forests, but no quick, accurate methods exist for estimating canopy fuels, which play a big role in wildfire behavior and



Steve Reutebuch

Airborne laser scanning systems (LIDAR) send 70,000 to 100,000 pulses per second to the ground, yielding direct 3-D measurements of the ground surface and the forest vegetation.

rate of spread. Airborne laser scanning systems such as Light Detection And Ranging (LIDAR) are proving useful for quickly and accurately measuring tree height, canopy depth, and crown biomass over large areas, with a resolution of 1 to 2 feet.

LIDAR data were collected over plots in western Washington and compared with data from measuring canopies from the ground. Scientists found that laser scanning could not only map the ground surface accurately through canopies, but could also measure the canopies themselves with high accuracy. Field measurements for Douglas-fir canopies were highly correlated with the LIDAR measurements.

When further validated in other forest types, the technology promises to be useful for quickly assessing fuel loading and fire risk. The data may also help in predicting fire spread and intensity, especially for catastrophic crown fires. LIDAR flights are expensive but economical over large areas (\$1 to \$4 per acre). The flights can be done day or night, but require clear conditions.

Partners: Precision Forestry Cooperative, Joint Fire Science Program, University of Washington.
Lead: Pacific Northwest Research Station.

Creating Multiple-Value Forests With New Techniques

Society places many diverse demands on forests. Pacific Northwest Research Station scientists developed Active Intentional Management (AIM) for Multiple Values, an integrated system of techniques for managing a forest's multiple

ecological processes. AIM combines strategies for producing or enhancing different forest elements. These strategies include retaining mature trees, managing



Tom Iraci

Research at Capitol State Forest in Washington tests silvicultural regimes designed to manage for multiple ecological processes in a forest.

multiple species, keeping dead and dying trees as elements of stands, and thinning at varying densities in patches across the landscape.

The use of AIM principles resulted in successful on-the-ground management of lands managed by the USDA Forest Service, Washington State Department of Natural Resources, communities, and private owners. It was the preferred alternative for managing 2 million acres of Washington lands as well as for many USDA Forest Service timber sales and sales on a Vashon Island community forest.

Partners: Oregon State University; University of Washington; USDA Forest Service—Olympic National Forest; USDA National Research Initiative; U.S. Department of Defense—Army, Fort Lewis.

Lead: Pacific Northwest Research Station.

Demonstrating Conservation Silviculture in Hawaii's Koa Forests

Hawaii's koa is one of the world's most valuable trees. Converted to high-end furniture and accessories, it contributes tens of millions of dollars to the State's economy. Moreover, Hawaii's koa forests are habitat for one-third of the Nation's threatened and endangered species. But, like private forests elsewhere in the United States, Hawaii's koa forests are threatened by land development and conversion to other uses.

Working in partnership with The Nature Conservancy of Hawaii and Kamehameha Schools, USDA Forest Service scientists have developed new insights on the silviculture of koa. They have found that, after a disturbance, koa regenerates prolifically from long-lived seeds in the soil. Where seedlings are protected from grazing, young koa trees form dense stands with an understory of nonnative grasses. Thinning and grass control enhance the survival and growth of koa, leading to more valuable trees and improved conditions for native plants.

Scientists found that laser scanning could not only map the ground surface accurately through canopies, but could also measure the canopies themselves with high accuracy.

Demonstrating to private landowners that sound forest management is both economically and ecologically rewarding will help stem the conversion of privately held forest lands to suburban development and pastures.



Measuring koa after grass thinning.

Demonstrating to private landowners that sound forest management is both economically and ecologically rewarding will help stem the conversion of privately held forest lands to suburban development and pastures. This will help achieve landscape-scale conservation for these forests.

Partners: Kamehameha Schools; The Nature Conservancy of Hawaii.

Lead: Pacific Southwest Research Station.

Restoring Mixed-Conifer Ecosystems

Prescribed fire and mechanical thinning are widely used for restoring forest health. The Pacific Southwest Region spends upward of \$50 million each year to reduce fuels in California's forests, and

the need to address this crucial problem will persist for many years. Currently, forest managers are uncertain about how these two approaches differ in their ecological effects.

A team of more than 20 researchers and graduate students investigated ecosystem response to a combination of fire and thinning for 2 years before and after treatments (<http://teakettle.ucdavis.edu/>). The experiment was conducted at Pacific Southwest Research Station's Teakettle Experimental Forest on the Sierra National Forest, about 50 miles east of Fresno.

Their findings provide an indepth description of mixed-conifer ecosystems and how restoration treatments are likely to affect

them. Preliminary results suggest that restoring fire will be crucial to restoring forest function and process. Nevertheless, mechanical thinning is an important tool, and the first (or in some cases perhaps the only) option for realigning forest structure in many overstocked stands. Eventually, however, such initial treatments need to be accompanied by fire to effectively restore healthy mixed-conifer forests.

In 2004, seven research papers on the Teakettle experiment were accepted for publication as a special section in the journal *Forest Science*. These papers are the first of two planned special sections that will present the results of this 7-year project. Researchers have also produced

two PowerPoint slide shows communicating the results for forest managers and administrators. A third outreach product, a 25-minute DVD movie, will be finished soon.

Partners: California State University; Louisiana State University; Michigan Technological University; University Metropolitan, San Juan, Puerto Rico; University of California-Berkeley; University of California-Davis; University of Ohio; University of Washington; USDA Forest Service—Pacific Northwest Research Station.

Lead: Pacific Southwest Research Station.

Contributing to the Encyclopedia of Energy

As energy consumption has risen in the United States, the need to understand the technological, social, political, and environmental dimensions of energy has never been more urgent.

A new six-volume *Encyclopedia of Energy* published by Elsevier draws together all aspects of energy, covering broad areas throughout the natural, social, and engineering sciences. Rocky Mountain Research Station scientists in Albuquerque, NM, have contributed definitive articles to the book. The first, titled "Energy and Sociopolitical Collapse," was used by the publisher as a major part of the marketing program for the encyclopedia. The other, titled "Energy Flow in the Early Industrial World," discusses differences between energy systems based on fossil fuels and such renewables as forest products.

The United States' energy policy emphasizes expanded use of biofuels at the same time that forests are characterized by excessive biomass. The national forests have the capacity to contribute greatly to the Nation's biofuel needs. The contributions of station scientists to this distinguished publication show that USDA Forest Service energy research has gained international recognition.

Lead: Rocky Mountain Research Station.

Placing Value on Nonmarket Resources

As land management agencies in the United States and other countries struggle with managing public-land resources that fall outside developed markets, such as ecosystem

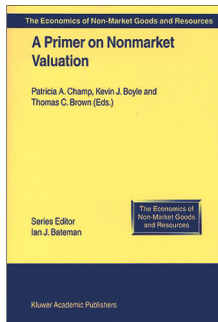
services and recreation, the topic of non-market valuation has become increasingly relevant. Many resource managers, however, have not been trained in nonmarket valuation techniques.

A Primer on Nonmarket Valuation, published by Kluwer Academic Press, was coauthored by Rocky Mountain Research Station scientists in Fort Collins, CO, to provide a resource for students, attorneys involved in resource damage assessments, and USDA Forest Service and other public land managers. The book defines “non-market valuation,” introduces the most widely used techniques, and explains the steps involved in implementing these techniques. The successful sales of this publication (it was in its second printing within months) reflect its timeliness and relevance.

A companion Web site is available at <http://www.fs.fed.us/nonmarketprimer-data>. It includes downloadable data sets for each of the techniques described, as well as links to published journal articles and reports based on the data. The Web site also enables users to estimate models by using the data.

Partners: University of Maine; various other academic institutions.

Lead: Rocky Mountain Research Station.



Making Fuel Reduction More Cost-Effective

As fire-prone sites in the West are treated to reduce fuels, a problem arises: What to do with the woody biomass that's taken off the site? Because many sites are not accessible to large grinding or chipping machines and many mountain roads are not designed for large chip vans, a lot of this material is simply piled for burning in the stand or left to decompose in roadside piles. Leaving piles of flammable material, however, does not completely remove the risk of future wildfires, and burning is often precluded by air-quality concerns.

A cost-effective transportation system is needed to collect these fuels and take them to centralized processing facilities, such as plants that use wood biomass for energy production. Several companies have been using roll-on/roll-off bins to transport woody biomass in a two-stage hauling operation. Slash is initially loaded into bins at remote forest operation locations, and then the bins are collected and hauled to a more accessible landing where the residues can be chipped and reloaded into trucks.

Can hauling biomass off the site be cost-effective in these circumstances? Researchers conducted a short field test of potential equipment to collect time and motion data, then used the data to develop a cost-analysis model that can evaluate a two-stage hauling system across a wide range of hauling scenarios.



The study showed that, because the bins have a payload of only about 9 tons, the initial haul should be as short as possible. Once the residues are chipped and reloaded, conventional highway-hauling economies of scale are realized, but the additional costs of transporting and rehandling the bins must be offset by some other factor.

The most likely application of this technology would be for transporting residues from a site that is near a facility that can use them but that is inaccessible to conventional hauling equipment.

Partners: Johnson Contracting; Missoula Cartage; Montana Community Development Corporation; USDA Forest Service—Forest Products Laboratory and Missoula Technology Development Center.

Lead: Southern Research Station.

Leaving Trees To Protect Streams: What Does It Cost?

Although streamside management zones are widely recommended for protection of water quality and are even required in some places, the costs associated with maintaining SMZs are not well documented. Research at the Southern Research Station assessed the commercial timber value of 20 watersheds in the Piedmont region and 20 watersheds in the Allegheny Plateau region before and after SMZs were established.

Four blocks were established in each region, and SMZs at five combinations of width (15, 50, and 100 feet) and harvest level (none versus 50 percent in the 50- and 100-foot SMZ widths) were installed in each block. The SMZs proved to be more costly in the Allegheny Plateau region, which has more high-value sawtimber, than in the Piedmont, which is characterized by pine plantations with low-grade hardwoods near streams; the average value of the residual timber was greater in the Allegheny region. Overall,

*Station and cooperators have launched the **Native Plants Journal**, which provides practical information about planting and growing native species.*



however, partial harvests are more economically sustainable in the Allegheny region because more desirable shade-tolerant species such as sugar maple grow along streams there, while in the Piedmont, partial harvests favor lower value, shade-intolerant species and were therefore less economically sustainable.

Lead: Southern Research Station.

Opening Access to Sweetgrass for Traditional Basketmakers

Sweetgrass is a nontimber forest resource used in basketmaking by the culturally endangered Gullah people of coastal South Carolina. Coiled basketry is a traditional African art form that was practiced for utilitarian purposes on plantations during the antebellum period. The making and selling of sweetgrass baskets has since become an important source of income for local African-American communities.

Urbanization has both reduced the amount of sweetgrass habitat and limited people's access to what remains because some of it lies in exclusive subdivisions. Today basketmakers tend to purchase the grass from commercial collectors, which

reduces their income and further endangers an important part of Gullah culture.

Scientists at the Southern Research Station are engaged in research to find solutions for the scarcity of this resource and to involve the public in making decisions about managing natural resources. Basketmakers have worked with researchers to develop a long-term management plan for sweetgrass. The plan identifies alternatives for sustainable management of sweetgrass, including setting aside accessible public land. It also points to the need for education of stakeholders in how to manage the resource, and for opening up lines of communication between basketmakers and landowners who restrict access.



Boy Scouts of the Coastal Carolina Council of the Twin River District have been working as volunteers to help install field studies and plant hundreds of seedlings. They have received local and national recognition for their efforts, including the Southern Research Station's Director's Award for volunteer service; the National Senior, Youth and Volunteer Programs Exemplary Volunteer Service Award; and a Daily Point of Light Award on September 29, 2004.

Partners: Boy Scouts of America; Citadel University; College of Charleston; DOC NOAA; USDA Forest Service—Francis Marion and Sumter National Forests.

Lead: Southern Research Station.

Launching Native Plants Research and Outreach

Invasive plant species threaten native plants in many areas, native plants sometimes need to be restored after wildfires, and Native American tribes across the United States want to bring their lands to a state more closely resembling that of presettlement times. Information about propagating native plants has never been more critical.

The Southern Research Station has led in the development and production of a native-plants program that includes publications, outreach to tribes and, eventually, greenhouses for propagating native container plants.

As part of this program, the station and cooperators support the *Native Plants Journal*, which provides practical information about planting and growing native species. The full-color journal is a joint effort with the Indiana University Press. In addition, recently published information on plant propagation is collected as Forest Nursery Notes and distributed twice yearly to a dedicated and supportive international readership.

More recently, through the native plants program the Southern Research Station and cooperators have established a new position for a tribal nursery coordinator, a botanist trainee with the responsibility for developing training programs for tribal members interested in native plant propagation and restoration. Interested tribal representatives have formalized their participation as the Intertribal Nursery Council.

The program has launched a number of other efforts:

- Development of Cultural Plant Propagation Centers for propagating native plants. The first of these facilities will be developed at the Hopi Reservation in summer 2005.

- A draft publication on propagation data for 300 species identified as important by tribal members.
- ▶ A *Native Plants Materials Directory* listing native-plant nurseries, seed dealers, and product suppliers.
- ▶ A *Tribal Nursery Manual* providing propagation technology in lay terminology.

The native-plants program is widely recognized within the USDA Forest Service and other USDA agencies because of its remarkable productivity and its effort to bring Native Americans into the mainstream of reforestation and restoration technology.

Partners: Intertribal Nursery Council; Indiana University Press; USDA Forest Service—NFS, State and Private Forestry; Western Forest and Conservation Association.

Lead: Southern Research Station.

Providing Accessible Recreation: New Surface Material

Researchers at the Forest Products Laboratory (FPL) in Madison, WI, have developed a playground surface material using inexpensive wood chips that could make playgrounds, paths, and other recreational facilities accessible to people who use wheelchairs or other mobility aids.

Because the wood-based material is considerably less expensive than most others on the market, it could help cities and school districts comply with requirements to provide access to people with disabilities. Such rules apply to tens of thousands of publicly funded playgrounds nationwide.

Working under a grant from The U.S. Access Board, researchers at FPL developed a surfacing material that uses a combination of wood chips and polyurethane. The surface, dubbed “stabilized engineered wood fiber,” is cohesive enough to support someone using crutches or a wheelchair, but it is resilient enough to cushion falls.

A playground surface material using inexpensive wood chips could make playgrounds, paths, and other recreational facilities accessible to people who use wheelchairs.



Steve Schmieding

The new surface was first commercially installed on a Maryland playground. On October 6, 2004, Ted Laufenberg of FPL, together with Prince Georges County Public Schools Maintenance Department and material supplier Zeager Brothers of Middletown, PA, installed the new surface under a new swing set at the H. Winship Wheatley Early Childhood Center in Capitol Heights, MD. The playground equipment had not been used until then because of the lack of a safe, accessible surface.

On October 21, 2004, Dr. Ann Bartuska, USDA Forest Service Deputy Chief for Research and Development, attended a ribbon-cutting ceremony at the Wheatley Center to dedicate the new accessible playground area.

Partners: Beneficial Designs, Inc.; U.S. Access Board; Wisconsin Department of Natural Resources; Zeager Brothers.

Lead: Forest Products Laboratory.

Removing Heavy Metals From Treated Wood

Chromated copper arsenate (CCA) has been an effective and widely used wood preservative. An estimated 60 billion board feet of CCA-treated products have been placed in service since the early 1970s. Because it contains heavy metals that can be harmful to humans and the environment, however, CCA-treated wood cannot be easily recycled, and nearly all CCA-treated wood is discarded in approved landfills. Methods are being developed to recycle CCA-treated waste wood, thereby reducing the potential for environmental contamination.

The FPL in Madison, WI, is taking a leading role in developing strategies for removing the preservatives from CCA-treated waste wood. An FPL research microbiologist developed a pilot-scale remediation process that involves treatment with a metal-tolerant bacterium

and a chemical extraction. The process removed 93 percent of the copper, 86 percent of the chromium, and 95 percent of the arsenic from flaked material. It removed 79 percent of the copper, 70 percent of the chromium, and 88 percent of the arsenic from particulate wood. On February 10, 2004, the microbiologist spoke of the technique in her keynote address to an international conference in Orlando, FL, on the environmental impacts of preservative-treated wood.

Remediating CCA-treated wood diverts waste wood from landfills and provides secondary products from the cleaned wood fiber. Cleaned material from this study has been reassembled into flake board and particleboard panels.

Lead: Forest Products Laboratory.

Improving Uses for Small-Diameter Logs

In the West, millions of acres of forest land are overcrowded and at risk for disease, insect attack, and, ultimately, catastrophic wildfire. Thinning these stands improves forest health, but the process is costly. Finding alternative and higher value uses for thinned material can help pay for thinning operations.

One alternative use for logs from small-diameter trees is in engineered structures and floor joists for log homes. Round timbers are currently assigned properties by visual grading techniques; these techniques, however, were developed for large-diameter logs. Little data exists to demonstrate how well visual grading can predict the structural properties of small logs.

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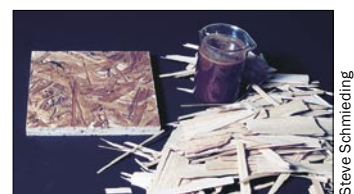
Researchers at the FPL in Madison, WI, in cooperation with the University of Idaho in Moscow and Timber Products Inspection Service of Vancouver, WA, are evaluating visual and mechanical grading techniques for small-diameter logs. Creating standard grading techniques will extend the possibilities for using small-diameter logs in construction.

Construction of engineered structures that use roundwood in the form of small-diameter logs is in its early stages. An example of this building technique is a library in Darby, MT, which was built from 6-inch-diameter lodgepole pine. The Darby Library held its grand opening in September 2004.

Lead: Forest Products Laboratory.

Developing Soy Glues: Better for the Environment, and Cheaper, Too

Before World War II, plywood panels were typically held together by an adhesive made from soy flour. Soy-based glues had problems with durability and posed some process difficulties, however, so synthetic materials replaced soy in wood adhesives. With increasing concern about formaldehyde emissions and rising costs of petroleum-based adhesives, new interest has developed in using soybean-based adhesives for wood bonding.



Steve Schmieding

Scientists at the FPL in Madison, WI, joined with private-sector colleagues to develop a viable adhesive from soybeans. The cooperative agreement between the FPL's adhesives group and Heartland Resource Technologies, an Iowa startup company, allowed several people from Heartland to work at FPL in a joint research program. Tandem programs were combined to gain a better understanding of the curing reactions of proteins with other chemicals, and the scientists ultimately developed a patentable soy-based adhesive technology that is proving to be of commercial interest.

The soy-based adhesive can match the performance of phenol-formaldehyde adhesives for the face portion of oriented-strand board. The adhesive uses less phenol and formaldehyde than conventional adhesive technology, it passes durability tests, and it is up to 50 percent less expensive. The results of several years of work were presented at the 38th International Wood Composite Symposium in Pullman, WA, on April 7, 2004.

Partners: Heartland Resource Technologies.

Lead: Forest Products Laboratory.

Finding a New Cure for Termites

A researcher from the FPL in Madison, WI, has found a promising new weapon in the battle against one of the country's most destructive insect pests, the Formosan subterranean termite (FST), an exotic bug that costs American consumers a billion dollars a year.

The researcher discovered that a commercially available naphtha-based compound called N-hydroxynaphthalimide (NHA) worked well to prevent decay-causing fungi from damaging wood. He also discovered that NHA was effective at killing common eastern subterranean termites.

The station scientist worked with two termite experts from the USDA's Agricultural Research Station in New Orleans. They developed a cellulose-based attractant to combine with the NHA. Their attractant was so appealing to the termites that FSTs would even carry the bait containing NHA back to their nests. In field tests in Louisiana and Mississippi, entire colonies of FSTs were eliminated in a matter of months, depending on the size of the colony.



Scott Bauer

Because the NHA termite bait is effective at low doses and, unlike most termiticides, contains no heavy metals, it is considered environmentally friendly and cost-effective.

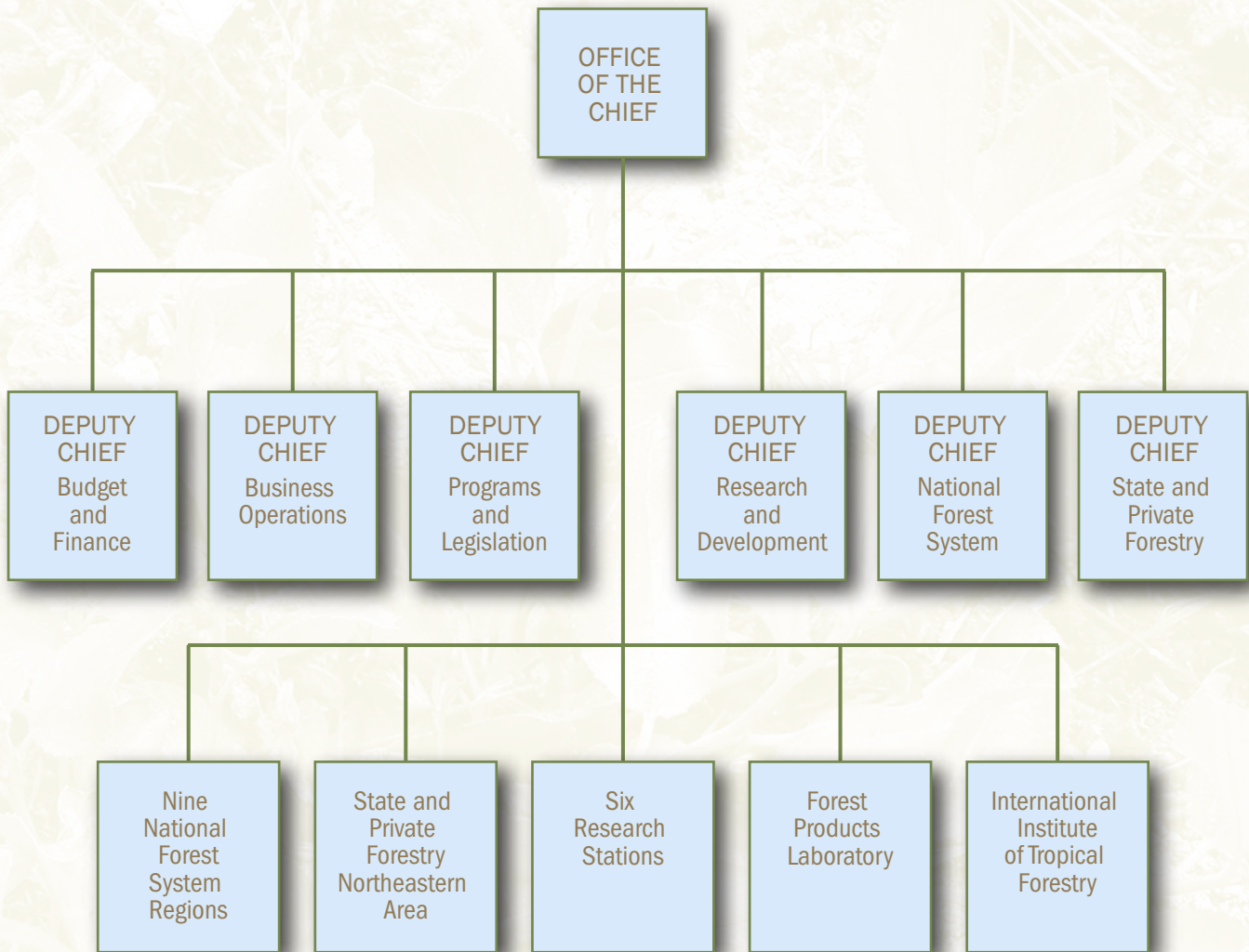
In 2004, the U.S. Patent Office issued a patent to the USDA for "Naphthalenic Compounds as Termite Bait Toxicants." A station scientist and the termite experts

were listed as the inventors. Recently, the USDA was awarded an exclusive license for developing, manufacturing, and marketing products based on the technology.

Partners: USDA Agricultural Research Station.

Lead: Forest Products Laboratory.

ORGANIZATION



Contacts



RESEARCH AND DEVELOPMENT DEPUTY AREA

Deputy Chief: Ann Bartuska
Associate Deputy Chief: Bov Eav
Resource Valuation and Use Research
Staff Director: David A. Cleaves
Science Policy, Planning, Inventory,
and Information
Staff Director: Richard W. Guldin
Vegetation Management and
Protection Research
Staff Director: Jimmy L. Reaves
Wildlife, Fish, Water, and Air Research
Staff Director: Deanna J. Stouder
USDA Forest Service
201 14th St., SW
Washington, DC 20250
<http://www.fs.fed.us/research/>

FOREST PRODUCTS LABORATORY

Director: Chris Risbrudt
One Gifford Pinchot Drive
Madison, WI 53726-2398
<http://www.fpl.fs.fed.us/>

INTERNATIONAL INSTITUTE OF TROPICAL FORESTRY

Director: Ariel E. Lugo
Jardín Botánico Sur
1201 Calle Ceiba
San Juan, PR 00926-1119
<http://www.fs.fed.us/global/iitf/>

NORTH CENTRAL RESEARCH STATION

Station Director: Linda R. Donahue
1992 Folwell Avenue
St. Paul, MN 55108
<http://www.ncrs.fs.fed.us/>

NORTHEASTERN RESEARCH STATION

Station Director: Michael T. Rains
11 Campus Boulevard
Suite 200
Newtown Square, PA 19073
<http://www.fs.fed.us/ne/>

PACIFIC NORTHWEST RESEARCH STATION

Station Director: Thomas M. Quigley
333 SW 1st Avenue
Portland, OR 97204
or
P.O. Box 3890
Portland, OR 97208-3890
<http://www.fs.fed.us/pnw/>

PACIFIC SOUTHWEST RESEARCH STATION

Station Director: Jim Sedell
800 Buchanan Street
West Annex Building
Albany, CA 94710-0011
or
P. O. Box 245
Berkeley, CA 94701-0245
<http://www.fs.fed.us/psw/>

ROCKY MOUNTAIN RESEARCH STATION

Station Director: Marcia Patton-Mallory
Natural Resources Research Center
2150 Centre Avenue
Building A
Suite 376
Fort Collins, CO 80526-1891
<http://www.fs.fed.us/rm/>

SOUTHERN RESEARCH STATION

Station Director: Peter J. Roussopoulos
P.O. Box 2680
Asheville, NC 28802
<http://www.srs.fs.usda.gov/>





USDA Forest Service
1400 Independence Ave., SW
Washington, DC 20250-0003

