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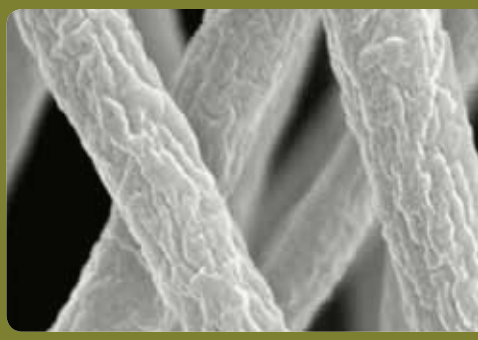


Science Serving Society




Contents

Welcome From the Deputy Chief

Managing in a Time of Austerity

Today's government managers know that smaller, leaner programs are our new reality. We are challenged in this new time of austerity to deliver relevant results with fewer resources and to stop doing a few things altogether if the resources are not available or the return on investment isn't sufficient. The change we are undergoing requires extreme focus on the most critical research topics, but I believe that we will emerge stronger for it and, through it all, continue to deliver quality science and technology to the American taxpayer.

One change I wholeheartedly embraced this year was the elevation of the agroforestry program, both within the Forest Service and across the U.S. Department of Agriculture (USDA). Agroforestry science and technology have made significant advances in the past 20 years due to Forest Service Research and Development (R&D) and State and Private Forestry (S&PF) investments in the USDA National Agroforestry Center (NAC) and the work of NAC's national network of partners. An expanded, science-based application of agroforestry is essential to realizing Secretary of Agriculture Tom Vilsack's vision of an all-lands conservation approach. As part of the new interagency agroforestry team, Forest Service R&D will play a key role in developing and delivering the science that helps landowners utilize agroforestry for both its economic and conservation benefits. The *Science Solution* article on agroforestry provides more detail on this program, and the sidebar to the article gives a great example of how research has already benefited one farm family economically.

My job as deputy chief includes some wonderful opportunities to get outdoors, meet new people, and communicate the importance of Forest Service research to the public. At the Priest River Experimental Forest Centennial in Idaho last September, I had a chance to do all three at once. The centennial included a re-enactment on horseback depicting the Forest Service employees who visited the area 100 years ago to designate it as one of the first Forest Service experimental forests. As someone who grew up in the country and still loves horses, it was a treat to take part in that event. The importance of our network of experimental forests and ranges cannot be overstated. They are "living laboratories" with a unique archive of long-term data sets for a range of studies. The event at Priest River gave me an opportunity to acknowledge their importance and thank the technical and administrative staffs for all their hard work in making Priest River a continued success. It also gave us an opportunity to bring a large group of young people to the site. As our current workforce ages and retires, we must be actively recruiting the best and brightest for the next generation of Forest Service researchers. Priest River was an excellent opportunity to do some informal recruiting with a lot of bright young people who attended the event. They were an impressive group in terms of interests and backgrounds, and their enthusiasm for pursuing a career in natural resources was just as strong as it was for me when I began my career.

We have learned over the years that hiring people from diverse backgrounds—and that includes factors such as age, geographic origination, and scientific training as much as race, gender, and ethnicity—can strengthen our technical capacity and add to our *esprit de corps*. But, we have not done enough to retain people once they are hired. Hiring is just the first step to a successful career with Forest Service R&D. Once people are onboard, it's our duty to provide an atmosphere of inclusiveness and mutual respect. Together with my Associate Deputy Chief Angela Coleman, we are revamping our onboarding process to get our new employees off to the best possible start. And we are on a continuous listening tour with our managers and our employees to ensure that all our employees, be they brand new, long term, or temporary, are set up for success.

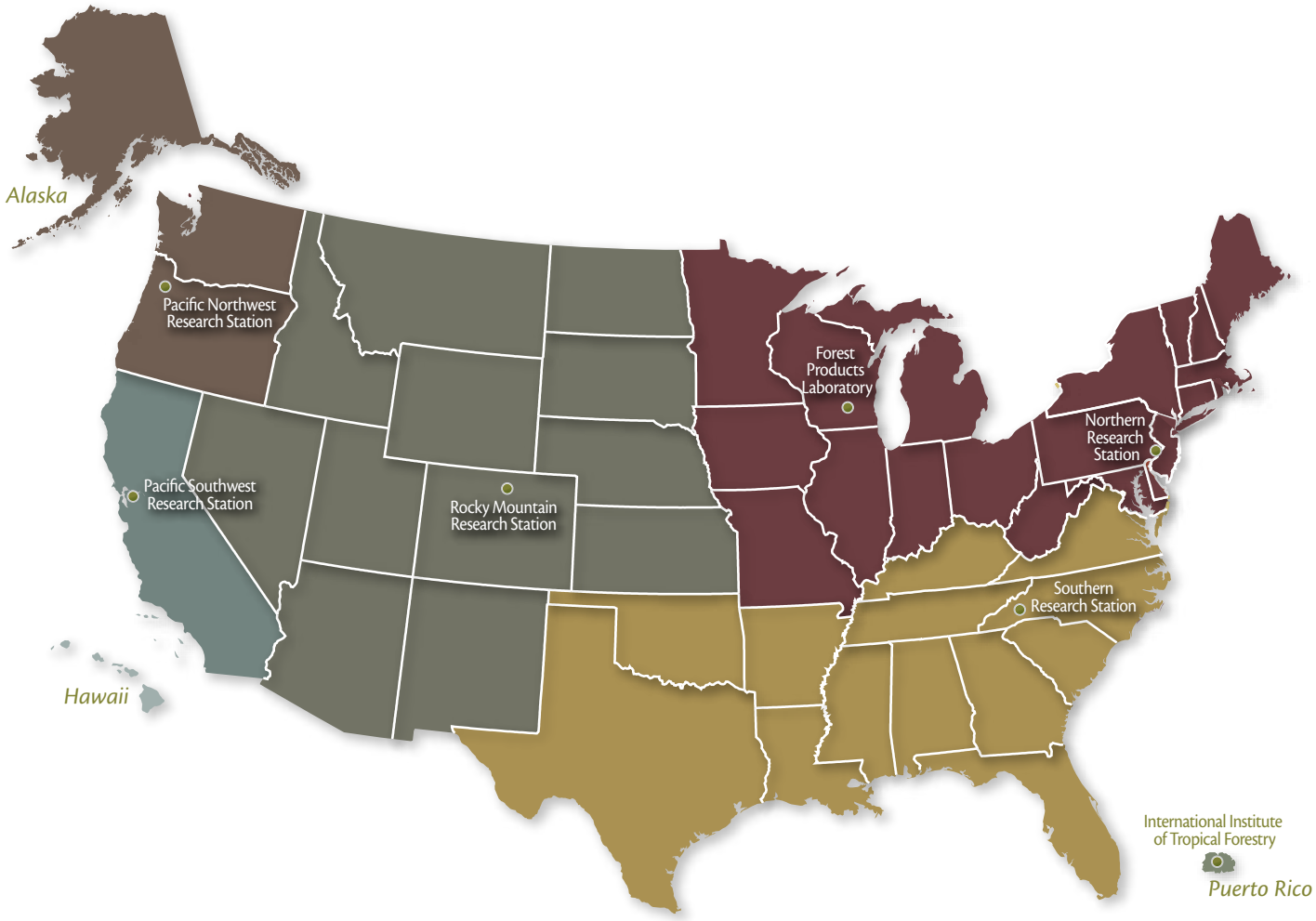
Just as our work with inclusiveness is open-ended, so is our commitment to building a safety culture. We recognize the importance of the safety of our employees and members of the public, because every human life is priceless and unique. Last year's earthquake in Washington, DC, was a stark reminder to all of us to be prepared! Fortunately, it was only some buildings, not employees, that sustained minor damage. Training is the key to behaving safely in emergency situations, as well as in routine endeavors. I'm happy to say R&D employees fell back on their training, evacuated safely, mustered in the appropriate places, and communicated with each other to ensure that everyone was accounted for. I'm proud of our response, but there is no resting on laurels when it comes to safety. We must continually train, review lessons learned at appropriate moments, and be constantly vigilant.

I want to close by pointing out that this issue of *USDA Forest Service Research & Development 2011 Highlights* summarizes the results from our research activities across the country and in foreign countries as past issues have done, and it incorporates two new features: *Profiles in Science* and *Science Solutions*. *Profiles in Science* give readers a glimpse of the people behind the science in the Forest Service. Where do they come from? Why do they do what they do? What are some of the most amazing or difficult experiences that they've had as scientists? These are some of the questions we hear over and over from young people who attend scientific conferences or career days at colleges and universities. We also

hear these questions from people of all ages and all walks of life at neighborhood block parties, sporting events, or any other gathering that attracts a cross section of Americans. As a scientist, I can vouch for the fact that my colleagues and I sometimes find it easier to talk about our research than ourselves. For those reasons, I'm delighted that this issue includes several *Profiles in Science* that convey how varied and interesting our scientists are and why so many of us choose to make a career of working in Forest Service R&D. The new *Science Solutions* feature case studies where a particular discovery or invention solved an existing problem or successfully met a difficult challenge. The *Science Solutions* show, I think, that we truly are living up to our motto of *Science Serving Society.*

Jimmy L. Reaves
Deputy Chief of Research and Development

USDA Forest Service Research Facilities



(U.S. Pacific Island Territories Not Pictured)




Forest Service Research and Development

Introduction

The research and development (R&D) arm of the U.S. Department of Agriculture (USDA), Forest Service, works at the forefront of science to improve the health and use of our Nation's forests and grasslands. Research has been part of the Forest Service mission since the agency's inception in 1905. Today, some 500-plus Forest Service researchers work in a range of biological, physical, and social science fields to promote sustainable management of the Nation's diverse forests and rangelands. Their research covers a lot of territory, with programs in all 50 States, U.S. territories, and commonwealths. The work has a steady focus on informing policy and land-management decisions, whether it addresses invasive insects, degraded river ecosystems, or sustainable ways to harvest forest products. The researchers work independently and with a range of partners, including other agencies, academia, nonprofit groups, and industry. The information and technology produced through basic and applied science programs is available to the public for its benefit and use.

Forest Service R&D organizes research under seven Strategic Program Areas (SPAs), which support an integrated approach to the study of broad, complex environmental and social issues. Within this structure, researchers address the Forest Service strategic goals and objectives at the watershed, landscape, regional, and national levels to focus research on the large-scale problems of national concern identified in the *USDA Forest Service Strategic Plan: FY 2007–2012*. SPAs provide consistent and stable, nationally strategic subdivisions of the national Forest Service research program for purposes of program development; management of review and oversight; communication to national audiences, including national interest organizations, the Administration, Congress, and the general public; budget formulation and presentation; and integration and collaboration among research stations and between stations and external partners.

Wildland Fire and Fuels

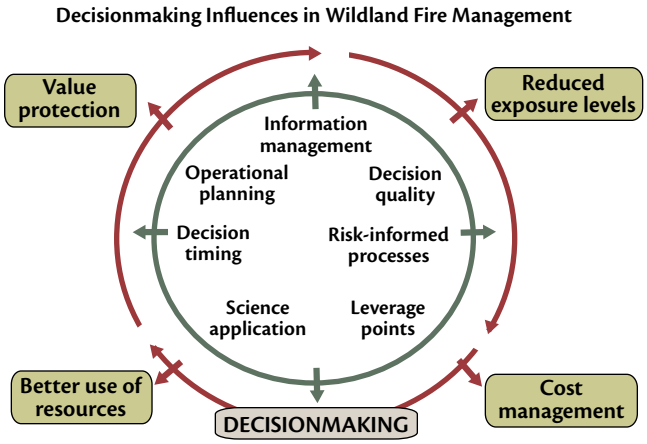
The **Wildland Fire and Fuels** SPA provides the knowledge and tools needed to help reduce the negative impacts and enhance the beneficial effects of wildland fire on society and the environment. It focuses on understanding and modeling fundamental fire processes, interactions of fire with ecosystems and the environment, and social and economic aspects of fire; evaluating integrated management strategies and disturbance interactions; and applying fire research to management problems.

Good Decisions for Good Fire Management

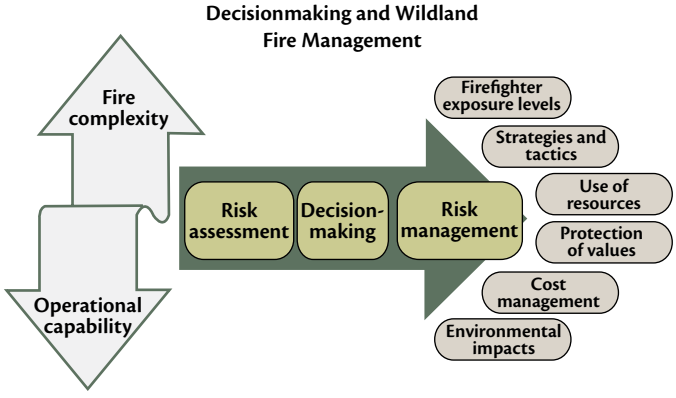
The Wildland Fire Decision Support System incorporates emerging science and technology into decision documentation, decision analysis, and long-term planning and implementation

Wildland fire complexity and challenges are intensifying, in part because of recent trends in shifting land use situations, fuel complex alterations, ecosystem health-induced changes in vegetation structure and composition, and fire response capabilities. Wildfire decisions have critical impacts and directly influence the strategies selected, tactics implemented, placement of firefighting resources, levels of firefighter exposure, costs expended, and environmental effects. Decisions are needed in compressed timeframes, and comprehensive risk-informed decisions are not possible without assessments of risk. The Rocky Mountain Research Station's Wildland Fire Management Research, Development, and Application program is developing the Wildland Fire Decision Support System (WFDSS) to incorporate emerging science and technology into decision documentation, decision analysis, and long-term planning and implementation. WFDSS bundles together analytical tools that rapidly analyze information, help to reduce uncertainty, and support response decisions. It contains multiple risk assessment processes, ranging from rapid qualitative methods to more detailed quantitative analysis procedures that provide information commensurate with shifting complexity levels. The development and application of this comprehensive decision support system greatly enhances the U.S. wildland fire management program. WFDSS is currently in use by all five Federal wildland fire management agencies. Additional information on the WFDSS is at http://wfdss.usgs.gov/wfdss/wfdss_home.shtml. Learn more about the Wildland Fire Management Research, Development, and Application program at http://www.wfmrda.nwcg.gov.

Lead: Rocky Mountain Research Station



▲ A number of factors interact to affect sound decisionmaking in wildland fire management and influence broad program goals and ultimate outcomes. *Tom Zimmerman, Forest Service*



▲ With fire complexity escalating and operational capability decreasing, the process of wildland fire management decisionmaking has become increasingly more important. *Tom Zimmerman, Forest Service*

Fireflux Experiments Improve Safety of Prescribed Burns in the New Jersey Pine Barrens

Predicting the effects of smoke from low-intensity prescribed fires on local air quality is easier with new tools developed by Forest Service scientists

▲ Instrumented towers set up within and in the vicinity of prescribed fires in the New Jersey Pine Barrens provide critical meteorological and air quality data for validating smoke prediction tools. *Nicholas Skowronski, Forest Service*

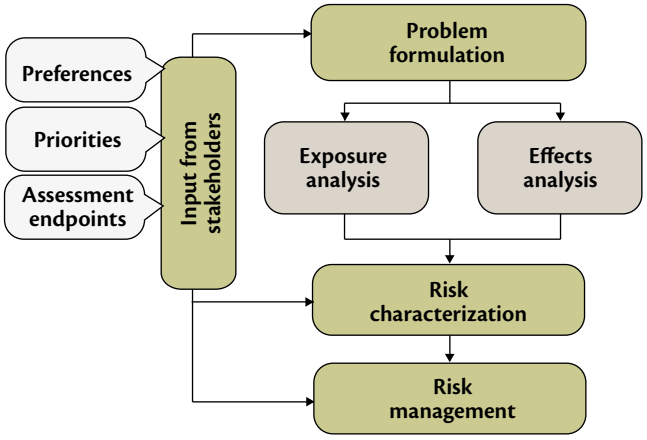
Prescribed fires are an essential fuels management tool for enhancing ecosystem health and protecting people, homes, and property from wildfires. Prescribed fires near urban centers or areas where air pollution is already a problem may cause smoke that exceeds Federal, State, or local air-quality standards. Three large fire–fuel–atmosphere interaction (also known as Fireflux) experiments measured fuel loading and consumption, atmospheric turbulence, fluxes of energy, water vapor and carbon dioxide (CO_2), and smoke transport at the landscape scale during operational prescribed fires on the New Jersey Pine Barrens. Results from the experiments indicate that most of the heat and water vapor released from consumed fuel is indeed captured by flux measurements, and that particulate matter ($PM_{2.5}$) concentrations rapidly returned to below U.S. Environmental Protection Agency standards after flames passed. Measurements of fuel consumption, fluxes, and atmospheric circulations during fires are essential for evaluating and improving predictive models that fire and land managers use for prescribed burn planning and smoke management. Research included partners in the New Jersey Forest Fire Service, New Jersey Department of Environmental Protection, Michigan State University, and Ohio State University.

Lead: Northern Research Station

Assessing Wildfire Risk to Communities and Natural and Cultural Resources

Forest Service scientists are working closely with the agency's Western and Eastern Threat Centers to develop novel methods to assess wildfire risk to communities; watersheds; wildlife habitat; and developed, natural, and cultural resources

Climate change, increasing human development into fire-prone areas, and the accumulation of fuels from historical management practices, among other factors, have led to increasing complexity, difficulty, and costs of wildfire management within the United States. It is crucial that areas of high wildfire risk and options for mitigating that risk be identified and evaluated. Rocky Mountain Research Station scientists affiliated with the National Fire Decision Support Center, in cooperation with the agency's Western and Eastern Threat Centers, are developing novel methods of assessing wildfire risk to communities, watersheds, wildlife habitat, and natural and cultural resources. Researchers pair outputs from wildfire simulation models with maps of highly valued resources and, where appropriate, with "response functions" that characterize fire effects. This approach is based on the U.S. Environmental Protection Agency's Ecological Risk Assessment framework, which incorporates resource exposure as well as the effects of that exposure. The risk assessment framework considers both beneficial and detrimental fire effects and can monitor trends in wildfire risk over time and space. Furthermore, the framework prioritizes investments in prevention planning, fuels management, landscape restoration, and suppression response. A key strength of the framework is scalability, meaning the same techniques and methods



▲ Key components of risk assessment are exposure analysis and effects analysis. This framework, employed by researchers, systematically portrays how fire likelihood and intensity influence risk to social, economic, and ecological resources. *Dave Calkin, Forest Service*

can apply from local to national planning scales. These new wildfire risk assessment methods form the scientific basis for the National Cohesive Wildland Fire Management Strategy, an effort of Federal, State, tribal, and local governments and nongovernmental organizations to address collaboratively the growing wildfire challenges. Researchers participate on analytical teams focused on furthering the science of wildfire risk analysis within the Cohesive Strategy and within other Federal programs, such as the Collaborative Forest Landscape Restoration Program. The assessment framework is helping to plan fuel treatments on the Deschutes National Forest in Oregon and to assess landscapes on the Beaverhead–Deerlodge and Lewis and Clark National Forests in Montana. Finally, results are being distributed through peer-reviewed literature to engage and seek feedback from the broader scientific community. These findings will lead to modifications of existing decision-support systems and, ultimately, to improved management of wildfire risk.

Lead: Rocky Mountain Research Station

Long-Range Prediction for Fire Danger and Fire Severity Now Possible

U.S. support center for wildland firefighting will access the information

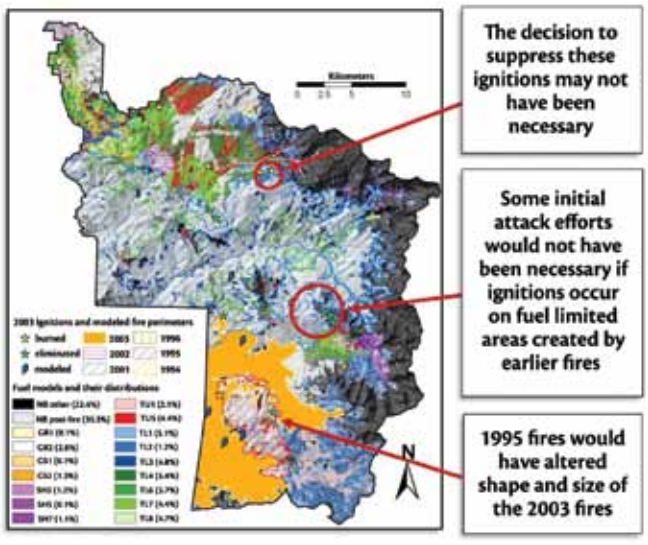
Predicting the influence of weather on fire ignition and spread is an operational requirement for national fire planning by the National Interagency Coordination Center (NICC), the U.S. support center for wildland firefighting. NICC's Predictive Services Program produces national wildland fire outlook and assessment products at monthly to seasonal time scales by considering standard Climate Prediction Center seasonal forecasts of temperature and precipitation, along with other factors, including human judgment. The long-established practice of fire danger assessment in the United States follows the procedures of the Forest Service National Fire Danger Rating System (NFDRS). The NFDRS computes current fire danger from weather variables observed over an automatic national network or the National Weather Service (NWS) 7-day forecast products. These fire danger maps automatically update daily, but they fall precipitously short of the long-range products required for the Predictive Services Program. Recently, the NWS National Centers for Environmental Prediction (NCEP) introduced the Climate Forecast System (CFS), which starts from operational analyses running ocean-atmosphere-coupled global models and performs the dynamical climate prediction with up to 7 month's, lead time. Working with scientists from NCEP and Scripps Institution of Oceanography, Experimental Climate Prediction Center, Forest Service scientists use the CFS to provide spatial and temporal boundary conditions for higher resolution regional climate model prediction—essentially downscaled global short-term climate forecasts—over the contiguous area of the United States. The Forest Service subsequently computes the fire danger indices of NFDRS from the predicted weather variables. The scientists found that these indices can be predicted skillfully at weekly to seasonal time scales by the downscaled forecast system. The potential of this long-range forecast is not limited solely to fire danger prediction. The research team has also demonstrated that such dynamically forecasted NFDRS indices can be part of an empirical model to project the probability of fire occurrence and severity. Researchers are developing such a seasonal forecast product with forecasters at NICC to match the planning horizon of the Predictive Services Program.

Lead: Pacific Southwest Research Station

The Hidden Consequences of Fire Suppression

A new guidebook helps managers conduct comprehensive cost-benefit analyses of different response strategies

For decades, the Forest Service's principal objective for managing fires has been suppression, even in remote areas. But does this strategy, although seemingly beneficial in the short term, have hidden costs? What if the agency did not suppress those fires? Where would those fires have spread, and what would the effects have been? Can the effects of suppressing



▲ Simulations show where fires would have spread and reveal hidden consequences of suppression. *Carol Miller, Forest Service*

those fires be measured? Rocky Mountain Research Station scientists recently quantified many of the hidden consequences of fire suppression. They found that burned areas from previous fires would have curtailed the growth of many fires. This finding clearly demonstrates how fires can create barriers to future wildfires in the form of fuel breaks—lessening the risk of catastrophic wildfire and potentially making it easier to manage the next wildfire safely. Studies also illustrate another hidden consequence of suppression: many ignitions would not have occurred because they were located on areas where an earlier fire would have left little fuel remaining on the site. Scientists obtained these findings—that fires dramatically alter the number of subsequent ignitions and the extent of fire spread—by using a novel combination of fire behavior modeling technology, Geographic Information Systems, and local expertise. The results of this research have broad national applicability, and a step-by-step guidebook for managers to conduct similar analyses elsewhere has documented the research methods. In fact, these very methods are currently being used to conduct a comprehensive cost-benefit analysis of different response strategies for three large wilderness landscapes in the northern Rockies and the Southwest. This research is improving the prioritization and planning of fuels management activities nationally. It also is enabling managers to frame future decisions and cost-benefit analyses in the context of past experiences, track the cumulative effects of suppression, and communicate tradeoffs to the public. Findings are also improving the quality and consistency of fire- and fuels-management decisions and helping managers devise safe and effective strategies that capitalize on the opportunities for a wider use of fire. Finally, this research highlights the importance of wilderness

Profile in Science—Connie Millar

Scientist studies pika and its effect on global warming

▲ Connie Millar, Forest Service Scientist. *Forest Service*

Connie Millar is about as quick and nimble as the American pika that she studies. Darting here and there on the talus (rocky formations) where the small alpine mammal lives, Millar is a blur of activity. She has covered every peak above the Mono Basin, where she typically spends summers studying the pika. A forest ecologist and an expert on mountain ecosystems for the Forest Service Pacific Southwest Research Station in Albany, CA, Millar began observing pikas in 2007 as part of her research on climate change and its effect on subalpine environments.

As members of the rabbit family, pikas are poor thermal regulators and do not dissipate heat well, so they must find a cool environment to survive. With thick fur and high basal metabolisms, they are much more suited for colder temperatures.

Millar was not convinced by such apocalyptic scenarios and set out to make her own determination about the fate of the pika. She found their range to be quite broad in the region where she worked, from 1,800 to 3,900-plus meters, and that they are widely distributed throughout the Sierra Nevada and the western Great Basin. She then collected data on the conditions in which pikas live. Using small temperature sensors (iButtons) to measure the temperature on top of and below the talus, Millar found that, while surface air temperatures rose to a lethal level for pikas, much cooler conditions prevailed under the rocks. Millar concluded that pikas are able to adapt behaviorally by seeking refuge in talus fields, which trap the cold nighttime air, creating a cool environment during the day.

She plans to continue monitoring pika sites to see whether they are in fact moving upslope to escape rising temperatures. But in the meantime, the pika appears to be here to stay.

"My interpretation of what we've seen so far suggests that they have a good stronghold and that even if some of the environments were to become inhospitable, there is an enormous range of habitats," Millar said. "I would say that the future of American pika in the Eastern Sierra looks very good."

When she is not in the field observing pikas, Millar gains great insight from her pet house rabbits—Tundra, Taiga, Zipper, Ruby, and Pepper.

"They have taught me so much about the behavior and ways of pikas, which are so different from rodents," Millar says of her warren of rabbits, which are free range and have their own bedroom in Millar's home.

Although her fieldwork can be a solitary pursuit, Millar also works collaboratively with fellow researchers as director of the North American chapter of the Global Observation Research Initiative in Alpine Environments, co-director of the California Pika Consortium, and chair of the Consortium for Integrated Climate Research in Western Mountains.

areas for research because they are natural systems in which ecological processes are allowed to play out, and they are essential for understanding fire ecology within wilderness areas as well as within more heavily managed landscapes. For more information, visit http://leopold.wilderness.net/research/fprojects/f006.htm.

Lead: Rocky Mountain Research Station

Impediments to Woody Biomass Utilization on Federal Lands

Forest Service scientists study the social dynamics of biomass use

Although the increasing utilization of woody biomass from Federal lands is potentially a key part of facilitating fuels treatments on Federal lands, efforts to increase utilization have met with limited success. Forest Service researchers studying the social dynamics of biomass use on 10 sites on Federal lands, therefore, paid particular attention to assessing the reality of persistent conventional wisdom about what limits utilization. Because "accepted truths" are not necessarily accurate, they can negatively influence the framing of problems and actions. The researchers found that the conventional wisdom was reasonably accurate, although the degree to which each impeded progress varied. Research partners include University of Minnesota, Michigan Technical University, and University of Oregon.

Lead: Northern Research Station

▲ Conducting fuels reduction in mix coastal species in southern Oregon. *Dennis Becker, University of Minnesota (used with permission)*

▲ Biomass receiving gate for a Burlington Electric power station. *Dennis Becker, University of Minnesota (used with permission)*

Profile in Science—Paulette Ford

Forest Service scientist chooses a "natural" life

▲ Paulette Ford, Forest Service Scientist. *Forest Service*

Paulette Ford is a research ecologist with the Forest Service Rocky Mountain Research Station. She traces her interest in the natural world back to her childhood, when her family was stationed on a U.S. Naval Base in Morocco for a couple of years. With no television on base, she read a lot, mostly encyclopedias, and played outdoors. That experience formed some lifelong habits. Today, as a scientist based at the agency's Albuquerque research unit, Ford splits her time between field research on large landscapes, such as the Kiowa National Grassland or the Sevilleta National Wildlife Refuge in New Mexico, and writing papers about that research, which can take decades to fully understand in the light of climate change.

"I like to get a hold of a big system and manipulate everything in it," she said. "As a scientist, I'm a generalist. I design big studies and pull in the specialists to get the expertise I need for specific aspects of the project; for example, I might pull in a statistician to help me sort out the data." She has invested a number of years studying prairie dogs.

Ford began studying prairie dogs because billionaire environmentalist Ted Turner contacted her program to see if it could help re-establish prairie dogs on his New Mexico ranch. "People seem to love them or they

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want to shoot them," she said. To a research ecologist like Ford, prairie dogs are "environmental engineers" that alter large ecosystems—their colonies can go on for miles—and provide habitat for other species. After a colony dies out because of disease or moves on because of some other disturbance, its large underground burrow can be inhabited by endangered species such as the black-footed ferret and other burrowing mammals. For these reasons, ecologists consider prairie dogs a "keystone species."

The 1997–1998 drought in the Southwest wiped out the high vegetation on her research site and prairie dogs moved in because they prefer low grass. She remembers watching them "engineer" the environment. "They toss sod up like crazy when they dig out their burrows. It's fun to watch." She describes her current research as understanding the role of disturbance in structuring grassland, desert, and woodland communities and ecosystem resilience in the wake of a big disturbance.

It seems fitting that Ford designs field studies around disturbance because it was a natural disturbance that put her on her current research track. As a Ph.D. student, Ford was a cooperative education student with the Forest Service, studying amphibians in the Chihuahuan Desert, when drought hit. No frogs to study. Around the same time, one career scientist asked her to help with a newly initiated big fire study as her new Ph.D. project. The scientist changed labs a few years later, and Ford assumed full responsibility for the fire study.

"Eventually, the research expanded to include fire, drought, prairie dogs, and other mammals, because it all interacts," she said. The study is still one of her biggest projects—measuring the effects of season and frequency of fire in Shortgrass Steppe of the southern Great Plains. This long-term study examines the response to fire of multiple ecosystem components, including soil and plant nutrient cycling, and small mammal and invertebrate community structure. The study is in its 14th year.

Having now worked for the Forest Service for nearly 16 years, and having finished her Ph.D. in renewable natural resource studies in 2000, Ford has yet to be bored by the work or the agency. "I still think I have one of the best jobs ever," she said. "Although, there is less fieldwork, I have more time to analyze the big data sets I've collected and publish papers on my research." She reminisces about being a young scientist receiving reprints in the mail from her first published papers. Now her published works are available first online—not quite the same.

Ford still considers herself "a naturalist at heart," but she does think about moving up in management at some future point. "I believe the time will come when I can make a greater contribution by working in upper management." Even so, she doubts she will go that route until her big studies are wrapped up, and that will not be for a few more years. In the meantime, the fieldwork may have slowed, but her work schedule has not let up. Scientists from other U.S. organizations, as well as from other countries, seek her out more and more for joint studies, workshops, and symposia. She pulls out the photos from recent trips to Brazil and Australia. Dressed in field fatigues and a slouch hat, with a canteen and other equipment slung over her shoulders, the images conjure up exotic adventures.

Science Solution

Agroforestry—A Novel Management Approach for Many Landowners

Revenues rise along with productivity when agroforestry practices are put in place

Agroforestry intentionally combines agriculture and forestry to create integrated and sustainable landscapes that take advantage of the interactive benefits from combining trees and shrubs with crops and livestock.

Agroforestry practices can occur like a living patchwork quilt across entire watersheds; for example, managed forest canopies in a woodland area can shelter a wide range of crops grown for culinary, decorative, and medicinal use—plants such as shiitake mushrooms, wild onions known as "ramps," ginseng, goldenseal, curly willow, and Galax. Likewise, farmers and ranchers who plant pine trees on land used for livestock and forage production can add to their profits by selling pine straw and high-value saw logs.

Agroforestry does not just benefit humans; it also protects the environment.

"Put trees to work on your land and watch them do important tasks like improve water quality, control soil erosion, increase agricultural production, and provide wildlife habitat," said Andy Mason, director of the USDA National Agroforestry Center and leader of the Interagency Agroforestry Team that includes representative from five USDA agencies (Forest Service, Natural Resources Conservation Service, Agricultural Research Service, National Institute of Food and Agriculture, and Farm Service Agency) and two key agroforestry partners (National Associations of State Foresters and Conservation Districts).

The USDA National Agroforestry Center, jointly sponsored by the Forest Service and the Natural Resources Conservation Service, works with partners to develop and deliver the science, tools, and training that help landowners and natural resource managers care for their land and maximize their profits. The center, administered through the Forest Service Southern Research Station in Asheville, NC, has a main office in Lincoln, NE, and a field office in Blacksburg, VA.

▲ Kathleen Merrigan (center) unveiled the USDA Agroforestry Strategic Framework, June 2011. *Forest Service*

To raise awareness and promote the science, practice, and benefits from agroforestry, USDA Deputy Secretary Kathleen Merrigan unveiled the USDA Agroforestry Strategic Framework on June 6, 2011, during the 12th North American Agroforestry Conference in Athens, GA. The framework lays the roadmap to influence the long-term health and sustainability of all lands for future generations.

"Agroforestry does not sacrifice farmland for forests or forests for farmland," Merrigan said. "Rather, agroforestry is the marriage of disciplines that, in the end, will protect our natural resources, benefit our communities and allow for the development of other sources of income for farmers, ranchers, and woodland owners. Agroforestry can enhance values for any landowner."

The framework is built around three simple goals: (1) adoption—increase the use of agroforestry by landowners and communities; (2) science—advance the understanding of and tools for applying agroforestry; and (3) integration—incorporate agroforestry into an all-lands approach to conservation and economic development.

Agroforestry provides benefits beyond rural areas. In rural–urban interface areas, agroforestry practices can improve wildlife habitat, mitigate the movement of odors and dust, serve as noise barriers, act as filters that help keep water clean, and do "double duty" as green spaces where food and other products can grow, while also providing a more pleasing place to work and live.

Agroforestry practices include riparian forest buffers along waterways; silvopasture systems with trees,

livestock, and forages growing together; alley cropping, which integrates crops, such as grains or vegetables, into alleyways with high-value trees and shrubs; forest farming, where nontimber forest products such as food, herbals, botanicals, and decorative products grow under the protection of a managed forest canopy; and field, farmstead, and livestock windbreaks.

As one of the most widely used agroforestry practices in the United States, windbreaks are a time-tested way of (1) reducing wind erosion; (2) protecting and increasing crop yields; (3) providing a barrier to reduce pesticide drift; (4) enhancing the living and working environment around farmsteads; (5) conserving energy; and (6) helping to reduce environmental stress on animals, feed consumption, and visual effects. These practices can be designed to accommodate many other purposes, such as odor mitigation, improving pollinator habitat, trapping snow, or producing biomass feedstock. The fundamental principle underlying the application of every agroforestry practice is putting the right plant in the right place for the right purpose.

Nontimber Forest Products Have High Economic Values and Growing Markets

U.S. forests are home to a wide range of healthy and delicious products, such as mushrooms and berries. The demand for nontimber forest products has grown rapidly over the past decade as more Americans discover their nutritional, medicinal, and culinary benefits.

Until recently, these products were simply harvested from their wild locations. Several products, like ginseng, goldenseal, black cohosh, and edible mushrooms, already have strong consumer markets; unfortunately, such high-value species can be overharvested, which threatens their long-term viability.

Agroforestry systems can offer solutions that allow a few of these plant species, like ginseng, to be cultivated under a forest canopy. Forests where valuable understory botanicals already exist need guidelines for sustainably harvesting them, while lands where these botanicals do not occur need an improved understanding of the site conditions required to establish them. The USDA National Agroforestry Center cooperates with universities, State forestry agencies, conservation districts, and nonprofit organizations to develop science-based guidelines for agroforestry cultivation systems for nontimber forest products to provide landowners with economic opportunities that they can readily integrate into their ongoing operations.

▲ Jim Chamberlain shows harvested wild onions, known as "ramps." *Forest Service*

In one such instance, an Illinois farm couple was trying to keep a perennial forest herb from crowding out other wildflowers on their 10.5 hectares of woodlands. When they contacted Jim Chamberlain, the center's research forest products technologist in Blacksburg, VA, they found out they could harvest native wild onions, known as "ramps," for income as part of their management plan to encourage other native woodland plants. In the first year of their new operation, they harvested nearly 4,000 pounds of ramps and several pounds of seeds. Within 3 years, ramps were providing almost 70 percent of their total farm income. The couple now also employs local workers to help with the harvest.

When life hands you a lemon, make lemonade, the saying goes. In this case, with the help of the USDA National Agroforestry Center, the landowners turned "weeds" into cash.

Wildland Fire and Fuels

Resampling Historical Inventory Plots Indicates Degree of Forest Changes Over the Past 100 Years

Research findings can be useful to managers and ecologists interested in restoring Sierra Nevada mixed-conifer forests

To document the degree of forest change over the past 100 years, researchers resampled plots within a 4,000-hectare area that the Forest Service originally inventoried in 1911. More than half the area had burned in relatively recent fires. This factor allowed for historical comparisons, both of areas that have experienced recent fire and of areas with no recent fire, to the same areas based on early forest inventories. The results indicate substantially altered forest conditions relative to the 1911 data and can be attributed largely to the disruption of the key ecosystem process for these forests—fire. Areas that burned recently showed a noticeable difference in forest structure based on fire severity. Current tree density and canopy cover in areas burned recently with moderate severity did not differ from 1911 estimates, but areas that burned recently with low severity and unburned sites had higher tree density and canopy cover relative to the 1911 estimates. This emphasizes an important distinction with regard to using fire to restore forests. Moderate severity fire that kills significant understory and intermediate trees came closest to restoring the early stand structure. The results also demonstrate a near doubling of live tree carbon stocks in the present forest compared with the historical forest. Research partners were Yosemite National Park, CA; University of California, Berkeley; and Salish Kootenai College, Pablo, MT.

Lead: Pacific Southwest Research Station

▲ A research plot within one of the historical timber inventory areas on which trees, surface fuels, and understory plants were measured. *Brandon Collins, Forest Service*

▲ Repeat prescribed fire intended to reduce fire hazard and restore historical forest conditions in a Sierra Nevada mixed-conifer forest. *Brandon Collins, Forest Service*

Study Identifies Landowners Likely To Benefit Most From Policies and Programs for Wildfire Risk Reduction

Primary residents and those living near public land are the most likely to treat their land to reduce wildfire risk

As wildfires consume increasing areas of Western U.S. forests each year, private landowners are becoming increasingly aware of the need to reduce wildfire risk on their property. Forest Service scientists wanted to know how nonindustrial private forest owners in eastern Oregon perceive and address wildfire risk. They discovered that 75 percent of surveyed owners of ponderosa pine forests had treated some portion of their land between 2003 and 2008. Primary residents were almost eight times more likely to reduce fire risk on their property than absentee owners. Also, owners living near public lands were more likely to manage their land, providing the added benefit of buffering fire risk between public and private land. Lack of knowledge or skills did not emerge as a significant barrier to fire risk management, implying that educational strategies may not be the best investment of public funds. Instead, owners indicated that they lacked sufficient resources to offset the costs of hazardous fuels reduction and that they would benefit from cost-share funds and markets for logs and wood products generated through thinning.

Lead: Pacific Northwest Research Station

▲ Defensible space in Idaho. *Sarah McCaffrey, Forest Service*

What Motivates Homeowners To Mitigate Fire Risk?

A study on homeowner support for defensible space, thinning, and prescribed fire found that most homeowners are supportive

In working to foster fire-adapted communities, individuals and organizations need to understand the dynamics of public support for fuels management on private and public land. A Forest Service research study on homeowner support for defensible space, thinning, and prescribed fire found that that most homeowners are supportive. They appreciated, understood, and supported the need for individual and agency action to mitigate the fire risk, a more positive picture of public response to the wildfire problem than is often assumed. Scientists from the Forest Service, Oregon State University, and Ohio State University interviewed 198 homeowners in 6 communities in Oregon, Idaho, and Utah about mitigating fire risk. Overall, they found a body of individuals who understood the fire risk and were taking numerous mitigation actions, thought the actions had reduced their risk, intended to maintain their work, and believed that it was their personal responsibility to take care of their own property. The main expectations of most homeowners were that Government agencies take care of Government land, provide information to homeowners about what they can do, and, in some cases, assist with vegetation disposal. Where Federal lands bordered communities (Utah and Oregon), the level of support for fuels management on adjacent public lands was high (83 percent found thinning acceptable, and 62 percent found prescribed fire around neighborhoods acceptable). This research demonstrates that understanding and support for wildfire mitigation on both private and public property are higher than is often assumed and highlights the importance of agency outreach activities.

Lead: Northern Research Station

Studies Shine Light on How Pine Beetles Affect Wildfire

Forests with a large number of beetle-killed trees are at a significantly higher risk of surface fires igniting the crown

Single-age stand conditions and warm climate patterns have led to a large-scale outbreak of mountain pine beetle (*Dendroctonus ponderosae*) throughout the Rocky Mountain West. Once infested, trees die, and their needles turn red. Scientists have debated the effect these beetle-killed trees might have on fire behavior, but know little as yet. For example, beetle-killed trees lose their needles over time, and after all the needles have dropped, crown fire danger largely disappears. But researchers currently do not know how long that process takes after infestation, and thus how long the trees remain at risk for crown fire initiation and spread. Moreover, these red-needled trees have lower foliar moisture content than unattacked trees, leading to increased crown fire potential. Initial findings on the time it takes for trees to lose their needles after a beetle attack indicate that some needles stay on trees for up to 4 years. Expanding the scope of the study, investigators are currently working with managers to

▲ Telltale red needles of a tree attacked by mountain pine beetles contain 10 times less water than those of a similar healthy green tree, and these low moisture contents cause the red foliage to ignite quickly and easily. This red-needle lodgepole pine tree was ignited from a single point source on its lowest branches; the entire tree was quickly consumed in flames. *Matt Jolly, Forest Service*

quantify crown fuel changes over time. This will help managers identify how long beetle-infested stands remain a crown fire hazard. Researchers also investigated the moisture content of beetle-killed foliage before needle loss. They found that red needles have 10 times less moisture than healthy foliage and that red needles ignite 4 times faster than green needles. Consequently, forests with a large number of beetle-killed trees are at a significantly higher risk of surface fires igniting the crown. Such low fuel moistures could also result in beetle-killed trees spotting ahead of the fire. This research provides insights into the potential use of fuel treatments in beetle-killed forests, increases firefighter awareness of dangerous situations, and helps managers identify areas at high risk for ignition and extreme fire behavior. The moisture study research is not yet published, but the team has presented preliminary results at two fire management conferences and in an Associated Press article.

Lead: Rocky Mountain Research Station

▲ Red-needled trees resulting from mountain pine beetle infestation. *Matt Jolly, Forest Service*

Fire Management Training and Tools Can Be Improved Through Understanding Potential Biases Affecting Wildfire Management Decisions

With proper education and tools, managers can overcome decisionmaking heuristics common to risk situations

Wildfire events are increasing in risk, intensity, and cost attributed to social (e.g., development in the wildland–urban interface) and environmental (e.g., climate) change. This research informs the understanding of how experience-based heuristics (potential biases) affect risk-based decisions surrounding wildfire management. Line officers and incident personnel in the Forest Service participated in an online experiment involving fire management scenarios. Findings showed that participants exhibited loss aversion, being more likely to choose a safe alternative among management options. They also focused more on decisions that reduced short-term rather than long-term risk. This tendency was less pronounced among experienced fire decisionmakers. However, those with more experience were also more likely to choose the status quo, which was typically suppression. Such decisions highlight the clear need for supporting tools and education to overcome these often-found patterns in the larger field of risk management. Some of these findings can be understood in light of factors external to the decisionmaker, such as pressure to suppress or extinguish a fire because of concerns over effects on air quality. Fire management policy changes across Federal agencies, and an increasingly educated and informed public regarding wildfire management, promise to augment manager education and decisionmaking tools in improving rational decisionmaking that incorporates long-term ecosystem health. Research partners included Ohio State University and Duke University.

Lead: Pacific Southwest Research Station

Prescribed Fire Combustion-Atmospheric Dynamics Research Experiment Advances Fire Science

Scientists pool their talent and resources to advance their understanding of fire behavior and fire effects

In the 21st century, wildfires are increasing in frequency, intensity, and complexity. These trends seem likely to continue in the face of climate change, shifting land use patterns, and an increasingly urbanized landscape. Application of prescribed fires, a best management practice in many forest types, could help reduce the looming wildfire threat but is becoming more and more challenging. Fire science must rise to these challenges in a timely manner but must address the need for greater collaboration and the pooling of talent and resources. This need led to the establishment of RxCADRE: the Prescribed Fire Combustion and Atmospheric Dynamics Research Experiment. The acronym reflects the collaborative nature of the experiment, which was born in 2008 as an

exercise to gather the talents of fire experts with a wide range of fire monitoring expertise and equipment from across the United States and Canada to instrument prescribed burns at Eglin Air Force Base and the Jones Center. Participants from the Forest Service, Eglin Air Force Base, University of Idaho, San Jose State University, Georgia Tech, Harvard University, Florida State University, Los Alamos National Laboratory, National Institute of Standards and Technology, U.S. Fish and Wildlife Service, The Nature Conservancy, Georgia Department of Forestry, and the Joseph

Profile in Science—Ann Lynch

Research entomologist studies how bugs interact with their environment

▲ Ann Lynch, Forest Service Entomologist, visiting Plain View Peak. *Boris Poff, Forest Service*

Ann Lynch loves to be bugged.

The research entomologist at the Forest Service Rocky Mountain Research Station studies how the environment reacts to insects and how Forest Service scientists can curb the damage. But she was not always a bug pro.

"I grew up a tomboy in rural Pennsylvania, loving everything about being in the woods," she said. At that time, however, the nontraditional roles for women seemed very limited. Lynch's high school teachers convinced her she was "smart enough to go to college," so she studied forest science at Pennsylvania State University and received a bachelor of science degree. Later she earned a master of forestry in natural resources biometrics science and a master's degree and Ph.D. in natural resources and pest management, all at the University of Michigan.

"I specialized in entomology because I love bugs and because I was fascinated that such tiny creatures could kill such large trees," Lynch said. "Plus, I wasn't patient enough to study timber or resource management—it takes many years to see the fruits of your labor in forestry."

"Historically, insect outbreaks have impacted, on average, larger areas each year than has wildfire, and often affect the same areas for several consecutive years," Lynch said. "But insects are key components of forested ecosystems, and outbreaks do not necessarily indicate that forests are unstable." Her research strives to distinguish between normal outbreak patterns and unstable conditions. Insects respond rapidly to new conditions, and she hopes that her research will also indicate the nature of outbreaks that we can expect in the future.

▲ Ann Lynchvisiting the Pinaleño Mountains. *Boris Poff, Forest Service*

Lynch's past research has included both insects and trees. She developed a means of using tree-ring analysis (with Thomas W. Swetnam, currently director of the Laboratory of Tree-Ring Research at the University of Arizona) to reconstruct 400-year-long chronologies of western spruce budworm outbreaks in Colorado and New Mexico. This work provided scientists with information on temporal and spatial variability in outbreak regimes and provided managers with information about how often they can expect outbreaks, how long those outbreaks might last, and how extensive the outbreaks might be.

She has also characterized spruce budworm outbreak severity associations with different ecological factors in northern Michigan, providing resource managers with information on hazard relationships that they could use to mitigate the effects of this insect. Also, she determined the life cycle of the exotic spruce aphid in southwestern montane forests and established what forest and weather conditions are associated with outbreaks, providing information vital to management of the endangered Mount Graham red squirrel.

Wildland Fire and Fuels

W. Jones Ecological Research Center joined in a series of prescribed fires with unprecedented measurement intensity. A subsequent RxCADRE in the spring of 2011 led to a formalization of the group and submission of a Joint Fire Science Proposal.

Forest Service scientist Joe O'Brien and his RxCADRE colleagues have pushed the field of fire science forward in several important ways. By combining an array of expertise to intensively measure large-scale experimental burns, RxCADRE has created data sets that many of the top fire behavior, atmospheric, and smoke dynamics modelers from across the country are using. The unprecedented detailed heat measurements taken in the experimental burns are improving fire effects models. For example, Forest Service scientists at the agency's Northern Research Station are planning to use some of O'Brien's data to improve tree stem heat transfer models and examine the impact of heat plumes rising through foliage on tree physiological damage. RxCADRE, although just beginning, has already proven fertile ground for establishing new collaborations among research stations, universities, and other agencies and has provided exciting new funding to deepen those collaborations.

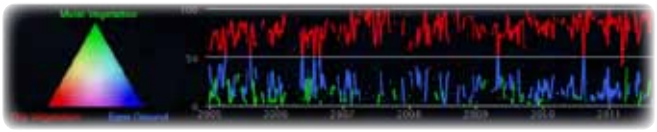
Lead: Southern Research Station

▲ Experts intensively measure large-scale experimental burns. *Forest Service*

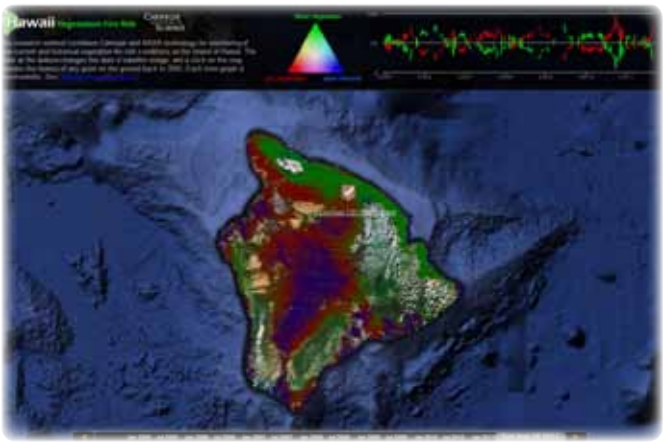
Scientists Develop Fire-Fuel Index for the Island of Hawaii Using NASA Terra Satellite Data of Vegetation Cover

Land managers can identify fire-risk patterns on the Island of Hawaii using the satellite imagery of vegetation fire risk conditions

Fires in Hawaii are fueled mainly by invasive, perennial grasses that maintain aboveground live and senescent biomass throughout the year. Researchers have developed a fire-fuel index for the Island of Hawaii at 500 meter spatial resolution using 8-day National Aeronautics and Space Administration Terra satellite data. The Terra satellite carries the Moderate Resolution Imaging Spectrometer, known as MODIS, which determined the percentage cover of vegetation. A Web-based version of the fire-fuel index that covers the entire Island of Hawaii enables land managers to track both current and historical (since 2005) high fire-risk days for their operations and to quantify the efficacy of their management efforts in reducing fire risk. Visit http://hawaiifire.stanford.edu for more information.



▲ Webtool combining Carnegie and NASA technology for monitoring of near-current and historical vegetation. *Strategic Environmental Research and Development Program (used with permission)*



▲ Historical to current patterns of fire risk on the island of Hawaii. *Strategic Environmental Research and Development Program (used with permission)*

Lead: Pacific Southwest Research Station

▲ Converted landscape from dry tropical forest to highly flammable nonnative grasslands. *Susan Cordell, Forest Service*

Fuel Treatments Mitigate Wildfire Effects in Northern Rockies

A case study provides solid evidence that fuel treatments generally mitigate severe fire effects

The costs of fighting wildfires have dramatically increased in the past decade, as have the size and severity of wildfires. Many of the millions of dollars spent fighting fires are spent in the wildland–urban interface (WUI), where expanding development into the forest creates more and more homes that are threatened when wildfires inevitably occur. The Forest Service has sought to reduce the rapidly rising costs of fighting wildfires by thinning forests and removing fuel in the WUI before a wildfire occurs. These fuel treatments have amounted to millions of acres treated at a cost of millions of dollars, which, since 2000, the National Fire Plan (NFP) has largely funded. But is this proactive strategy working? The year 2007 was an exceptionally active fire year in the northern Rockies, the most active in Idaho since the historic "Big Burn" of 1910. In central Idaho alone, several massive wildfires combined to create the East Zone and Cascade megafires, which burned more than 240,000 hectares and cost more than $70 million to try to suppress. Weather conditions were so extreme, however, and the wildfires so dangerous that firefighters could do little beyond evacuating people and protecting property. Two local communities—Secesh Meadows and Warm Lake—were directly in the path of these advancing wildfires. Fortunately, no lives or homes were lost. Firefighters credit NFP-funded fuel treatments located immediately adjacent to structures for slowing the momentum of the advancing crown fires. But did the fuel treatments also mitigate severe fire effects? The fact that extreme crown fires tested these fuel treatments provided the agency's Rocky Mountain Research Station and collaborating University of Idaho fire ecologists with an opportunity to assess whether fuel treatments also mitigate severe fire effects on vegetation and soils. Researchers found the answer to be a qualified "yes." The severe wildfire killed most trees, but fewer on treated sites than on untreated sites. Furthermore, most trees on untreated sites were completely charred, while trees on treated sites dropped their scorched needles in the weeks following the wildfire, helping to protect the soil from erosion. There were exceptions: some treated sites in which the piled fuel from forest thinning remained experienced more severe wildfire effects than adjacent untreated sites. Nonetheless, this case study provides solid evidence that fuel treatments generally do mitigate severe fire effects. The study also reviews and corroborates dozens of previous retrospective, but often anecdotal, studies that support a widely held consensus among forest managers that forest thinning followed by some form of fuels removal, such as prescribed burning, is the most effective fuel treatment strategy. The benefits of fuel treatments as documented through this comprehensive study (http://www.treesearch.fs.fed.us/pubs/37405) will help incident commanders, fuel specialists, forest planners, and national policymakers make wise decisions.

▲ Crews spread foam on a fire to defend a home in Secesh Meadows, ID. *Andrew Hudak, Forest Service*

▲ Secesh Meadows pile-and-burn-treated site (left) and its paired untreated site (right) 1 year after the fire. *Andrew Hudak, Forest Service*

Lead: Rocky Mountain Research Station

Wildland Fire and Fuels

Multiple Fuel Treatments Likely Needed To Restore Resiliency in Fire-Adapted Ecosystems

Fuel reduction and restoration treatments can begin restoring late-successional stand structure, but single treatments are insufficient to mitigate structural changes resulting from a century of fire exclusion

Across the Western United States, the structure of many low-elevation dry conifer forests is considerably different than it was before Euro-American settlement. These altered conditions contribute to the increased probability of unnaturally severe and extensive wildfires. Strategies for reducing fuels and restoring fire-adapted ecosystems include thinning live and dead trees and burning surface fuels to reduce the risk of severe surface and crown fires. In the past decade, Federal and State agencies have reduced hazardous fuels on nearly 77,700 square kilometers. These treatments may be effective in initiating short-term changes in forest structure and may shift existing diameter distributions toward those that might persist in late-successional forests, but single treatments or entries are insufficient to mitigate structural changes resulting from nearly a century of fire exclusion. This work was part of the National Fire and Fire Surrogates Study; research partners included University of California–Berkeley; University of Montana; U.S. Geological Survey; and Forest Service National Forest System (NFS), Pacific Southwest Research Station, and Rocky Mountain Research Station.

Lead: Pacific Northwest Research Station

▲ A stand of ponderosa pine in central Oregon after thinning and prescribed burning. *Tom Iraci, Forest Service*

Research Seeks To Understand the Physical Processes of Fire Spread

A completely new approach to understanding and modeling the spread of forest fires leads to models for fire management applications

Despite the many operational models now used in fire management, the physical processes responsible for fire spread are not well understood. Advancements are hindered by a variety of factors, including a lack of a basic understanding of crown fire spread and spread thresholds, the implications of mountain pine beetle attack on crown fires, and fire and fuel dynamics of crown fire ecosystems. To address this, researchers are working to develop new approaches and theoretical understanding of fire spread under various conditions. Supported by the National Fire Decision Support Center, studies at the Rocky Mountain Research Station address the following questions: (1) Why is radiation insufficient to heat fine fuel particles to ignition? (2) What is the structure of turbulent flames at their edge, and how well do simple turbulence models characterize it? (3) What is the critical mass loss rate for ignition of live and dead wildland fuels? (4) What are the properties of live fuels that allow them to ignite, lose

▲ Laboratory experiment showing flame wall apparatus, sensor placement, and close-up of turbulent eddies intersecting the heat flux sensor and thermocouple arrays. *Mark Finney, Forest Service*

moisture, and burn? Laboratory experiments suggest that the radiant intensities found in wildland fires are not sufficient to ignite fine fuel particles such as needles and grasses, but flame convection provides the critical heating of particles to ignition. Moreover, other experiments show that the edges of turbulent flames are responsible for igniting fuel particles after subjecting them to intermittent heating and cooling over time scales of about 0.1 seconds. Researchers also discovered that the ignition of wood depends on a critical rate of converting solid mass to combustible gas similar to other substances (such as plastic), and that ignition depends on the heat flux and wind flow, providing an improved definition of ignition and flammability limits. Finally, research shows that live fuels such as conifer foliage can burn at moisture contents many times higher than dead fuels because they release moisture explosively compared with slow diffusion in dead fuels and because they contain large amounts of nonstructural carbohydrates. This research suggests a completely new approach to understanding and modeling fire spread that is based on an experimentally supported theory, creating new opportunities for developing models for fire management applications. More information is available at http://www.treesearch.fs.fed.us/pubs/39350.

Lead: Rocky Mountain Research Station

Science Solution

BAER Teams Welcome Input From BAERBONES Researchers

Scientists' findings and tools reduce postfire risk of flooding and erosion

▲ Pete Robichaud, Forest Service Scientist. *Forest Service*

The busy 2011 fire season in the Southwest brought together Forest Service scientists and Burned Area Emergency Response, or BAER, teams to undertake postfire assessments aimed at reducing the risk of erosion and flood. The Rocky Mountain Research Station "BAERBONES" Research Team, under the direction of research engineer Pete Robichaud, has been monitoring and modeling postfire erosion control treatments for more than 15 years. BAERBONES is not an acronym, according to Robichaud, but rather a play on the long-established BAER team function. Managers with BAER teams use various tools developed by BAERBONES, including an erosion risk management tool, known as ERMit, which the research team delivers to land managers through CDs and their Web site, http://forest.moscowfsl.wsu.edu/baertools.

BAERBONES Research Team members work collaboratively with colleagues on national forests to answer questions about soil erosion modeling, treatment selection, and expected benefits. For example, after the 2010 Twitchell Canyon Fire on the Fishlake National Forest in Utah, the team helped establish plots to monitor channel erosion following the installation of straw bale check dams. After the 2011 monsoon season, 22 personnel from the Fishlake National Forest worked with BAERBONES researchers to measure and remove sediment as part of the monitoring process. The research team also works with U.S. Department of the Interior agencies, the USDA Natural Resource Conservation Service, State and local governments, tribal governments, and foreign governments.

In the spring of 2011, the BAER community hosted the first "Burned Area Emergency Response (BAER) Treatment Effectiveness Training" Webinar. The BAERBONES Research Team was involved in Webinar planning and presented results on treatment effectiveness. The Webinar was well received by the management community, much like the other work of the BAERBONES Research Team. According to Russell LaFayette, regional hydrologist with the Eastern Region of the Forest Service, "The research team has made a significant contribution to the agency, the land we manage, and the taxpayers who fund BAER work. They have done and are doing meaningful work that helps real people in real time."

Invasive Species

The **Invasive Species** SPA provides the scientific information, methods, and technology to reduce, minimize, or eliminate the introduction, establishment, spread, and impact of invasive species and to restore ecosystems affected by the species. This research focuses on plants, animals, fish, insects, diseases, invertebrates, and other species that are not native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm.

Insects Used To Control Invasive Riparian Weed

Resource managers test a way to control leafy spurge without using herbicide that might damage other components of the riparian ecosystem

Riparian ecosystems are particularly sensitive areas, vulnerable to threats from invasive species and from the herbicide or pesticide options commonly used in uplands to control the invaders. Leafy spurge is one such invasive weed that has appeared along streams throughout much of the country. Forest Service scientists and collaborators set out to determine if releasing a large number of flea beetles (*Aphthona* spp.), an easily collected natural enemy of leafy spurge, could control the weed in infested riparian areas. They focused their efforts by releasing large, or "inundative," numbers of biological control insects on weed populations found in small, isolated patches along three streams in southwestern, central, and eastern Idaho.

They found that releasing 10 beetles per flowering stem had inconclusive, potentially small negative effects on leafy spurge biomass, crown, stem, and seedling density. But releasing 50 beetles per flowering stem reduced the biomass, crown, and stem density by 80 percent and seedling density by 60 percent compared with density in untreated plots. These findings enabled the Jordan Valley Cooperative Weed Management Area to receive a $25,000 grant to employ inundative beetle releases on leafy spurge in areas along tributaries of the Owyhee River in Idaho. The Salmon–Challis National Forest is using this protocol to reduce leafy spurge populations on islands in the Salmon River. Forest Health Protection personnel in Ogden, UT, effectively used inundative releases to control leafy spurge in regional riparian areas. The "Hold the Line" Program also used inundative releases of biocontrol insects to deter the spread of leafy spurge into the Yellowstone and Teton ecosystems. Research partners include USDA's Agricultural Research Service, Forest Health Protection; Rocky Mountain Research Station; Bureau of Land Management; and Idaho State Department of Agriculture.

Lead: Pacific Northwest Research Station

▲ Members of the Southern Idaho Biocontrol Program help with a study to determine if releasing large numbers of flea beetles is an effective way to control leafy spurge, an invasive weed. *Robert Progar, Forest Service*

Black Fingers of Death—the Bane of Cheatgrass

Scientists have identified a promising biocontrol organism that can kill dormant cheatgrass seeds and sometimes a high proportion of germinable seeds

Cheatgrass (*Bromus tectorum*) is an invasive plant affecting rangelands across the Intermountain West. Even after the successful removal of germinated seeds and established plants, ungerminated seeds in the soil can carry over across years and hamper the establishment of desired native plants. Rocky Mountain Research Station scientists have been addressing these issues, with focus on the ecology, population biology, and evolutionary genetics of both cheatgrass and its fungal pathogens. Biocontrol using naturally occurring fungal pathogens is a novel approach that can be a valuable tool for use in conjunction with other control methods. Currently, the most promising biocontrol organism under study is an ascomycete seed pathogen that can kill dormant cheatgrass seeds and sometimes a high proportion of germinable seeds. This pathogen (*Pyrenophora semeniperda*) has been dubbed

"Black Fingers of Death" because of the fingerlike, black fruiting bodies that protrude from killed seeds. Because Black Fingers of Death is a generalist pathogen, research has included a careful evaluation of its effects on nontarget host seeds under realistic field application scenarios. In some field inoculation treatments with the pathogen, researchers have achieved complete control of the dormant carryover seed bank, and negative effects on subsequently seeded native grasses were minimal. This research shows that seed pathogens can have important application in the control of weed seed banks in production agriculture, as well as on rangelands. Because of these studies, the goal of a practical, safe, and cost-effective commercial product for cheatgrass carryover seed bank biocontrol on rangelands is now potentially within reach. A patent application process for this biocontrol agent is underway through the Forest Service Patenting and Licensing Program, and collaboration with an industry partner to develop a marketable product is on track

Profile in Science—Bill Zielinski

A man studies how to manage other mammals

▲ Bill Zielinski, Forest Service Scientist. *Forest Service*

Growing up in the small suburban Milwaukee village of Brown Deer, WI, Bill Zielinski spent his boyhood days turning over rocks, identifying birds, and catching insects. He amassed quite a collection of insect specimens, ranging from butterflies to beetles. "I was fortunate enough to live during that heyday where we were given long leashes to run wild in the suburban fringes of our neighborhood and explore with our friends all the stories that the outdoors could tell us," Zielinski says.

Zielinski's interest in the environment grew during a two-semester high school course on conservation, where he learned how to survey and map streams, identify birds and trees, and collect scat and tracks from mammals. Perhaps it was serendipitous that Zielinski grew up in the same area where Aldo Leopold, the legendary conservationist, ecologist, and longtime Forest Service employee, made his mark on ecological restoration.

"He was the first department head at the nearby University of Wisconsin in the field of wildlife ecology," Zielinski said. "Although I didn't go to that school—I went to the University of Wisconsin, Stevens Point—all of us who were interested in the environmental movement idolized Aldo Leopold."

Although Zielinski did not have an opportunity to meet Leopold, who died in 1948, he was honored to begin his graduate career with Leopold's son, Starker, who invited Zielinski to study under his tutelage at the University of California, Berkeley, where Starker Leopold was a professor of zoology and forestry.

Zielinski says he loves science—a love stemming from the natural curiosity that he possessed as a boy—because it affords him the ability to ask big questions and then use logic and reason to find the answers.

"Science keeps your mind engaged and allows you to ask the questions: 'Why are we here?' 'How do we interact with other occupants on the planet?' Science allows you to explore," he said.

Zielinski started working for the Forest Service in 1992 and is currently stationed at the Pacific Southwest Research Station Arcata facility in northern California. His mission is to develop tools for public land managers that will help them make their own informed decisions, rather than merely telling them what course of action to take. His research focuses on understanding the effects of forest management on carnivorous mammals and developing survey and quantitative methods for studying mammals and biodiversity. The fisher and marten have been of keen interest to Zielinski. The weasel-related mammals are significant because, as predators, they transfer nutrients and energy within the ecosystem and have a disproportionate effect on other members of the ecological community in which they live.

Zielinski recently collaborated with colleagues at the Pacific Southwest Research Station, Craig Thompson and Kathryn Purcell, to study the vegetation attributes of the home ranges of fishers in the Sierra Nevada. Scientists can use the characteristics of these habitats to make assumptions about the suitability of other landscapes slated for potential vegetation management activities. Ultimately, these findings will enable land managers to better understand how their vegetation management activities, such as fuels treatment, will affect fisher habitat. Those findings will guide them to make better decisions.

to begin soon. Supporting publications and additional information are available at http://www.fs.fed.us/rm/grassland-shrubland-desert/research/projects/cheatgrass-biocontrol/.

Lead: Rocky Mountain Research Station

▲ Black Fingers of Death field study in northwestern Arizona. *Susan Meyer, Forest Service*

▲ Black, finger-like stromata (fruiting bodies) of the seed pathogen dubbed Black Fingers of Death protrude from killed cheatgrass seeds. *Susan Meyer, Forest Service*

Novel Fungus Helps American Chestnut Seedlings Survive in Reclaimed Mined Sites

Inoculated seedlings have improved nutrient and water uptake

As part of the American Chestnut Restoration Project, Forest Service scientists have planted thousands of blight-resistant American chestnut seedlings on reclaimed abandoned mined lands in southeastern Ohio. While evaluating various planting protocols, the scientists tested inoculation with several species of ectomycorrhizal fungi (which play a vital role in tree nutrition), including the well-known *Pisolithus tinctorius*. However, they found that a novel species of ectomycorrhizal fungus belonging to the genus *Scleroderma* was the most active and effective in the locations tested. This species appeared to be native to the reclaimed mined lands and

▲ Planting American chestnut on a reclaimed mine site on the Wayne National Forest. *S. Hiremath, Forest Service*

was aggressive in forming beneficial symbiotic association with chestnut seedlings, even replacing the other species. Identification through DNA sequencing indicated that the novel species was closely related to *S. areolatum* and *S. citrinum*. This newly identified novel ectomycorrhizal fungus appears to be better suited to form functional mycorrhizae under environmental extremes. Planning is underway for large-scale tests of this fungus for the restoration of chestnut and in reforestation efforts on reclaimed mined sites. This project was conducted in cooperation with Miami University, Oxford, OH.

Lead: Northern Research Station

Novel Symbiotic Fungus Enhances Beetle Invasiveness

Microsatellite markers, unique to these virulent fungi, enable rapid identification for use in an eradication program for the reinvading beetle/fungus symbioses

In the mid-1980s, the red turpentine beetle was inadvertently introduced into China from North America, along with its symbiotic blue-stain fungi. For the first decade or so after its introduction, the beetle went essentially unnoticed, although museum specimens date from that period in Chinese collections. More recently, the beetle/fungus combination became a very serious pest in China, killing millions of Chinese pines, which led to speculation that a new fungal associate may have arisen that enhanced the aggressiveness of the beetle/fungus complex. Forest Service researchers, in cooperation with the University of Pretoria, South Africa, and the Chinese Academy of Sciences, Beijing, conducted intensive surveys of the red turpentine beetle fungal associates in both North America and China to determine the geographic source and possible role of the fungi in the invasive success of the symbiotic complex in China. Using microsatellites, they discovered

▲ The red turpentine beetle, native to North America, was inadvertently introduced into China. *Dr. Runzhi Zhang, Chinese Academy of Sciences (used with permission)*

a novel fungal genotype in China that is far more virulent toward host pines than are the North American genotypes. These novel genotypes induce host trees to produce and release much higher levels of 3-carene, which is the primary host attractant of the red turpentine beetle vector. The result is a positive feedback mechanism that may have enhanced the invasive success of the beetle/fungus combination.

Researchers are concerned that this novel fungal genotype may find its way back to North America, with unpredictable consequences for native forests.

Lead: Pacific Southwest Research Station

Plant Chemistry Is Important in a Successful Biocontrol Program

A study reveals that insects affect weed chemistry in very different ways

Invasive plants and their negative effects on biodiversity and landscapes are one of the greatest threats to ecosystems, considered second only to habitat destruction. Biological control is one of the few tools capable of controlling widespread plant invasions. However, despite years of successful testing in the laboratory, many biocontrol insects fail to reduce weed populations after they are released in the field. A better understanding of the interactions between biocontrol agents and their weedy hosts is needed to more accurately

Science Solution

Wildlife Corridors Protect Animals and Humans

Geographic Information System models identify safe pathways to help maintain viable wildlife populations

▲ Peter Singleton collecting wildlife movement information in the Eastern Cascade Range, Washington. *Forest Service*

The millions of kilometers of highways that criss-cross the Nation are essential for human movement and commerce but also can be a recipe for ecological disaster for some wildlife communities. Roadways can carve up habitats, disrupt the natural migration of species, and result in collisions fatal for both animals and humans. For more than a decade, Forest Service ecologist Peter Singleton has been exploring ways to preserve habitat connectivity and landscape permeability in the Pacific Northwest.

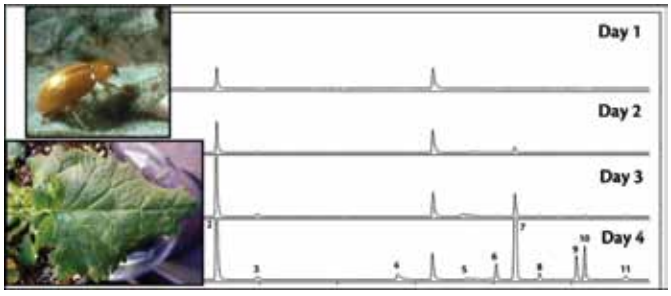
At the heart of Singleton's work is a suite of Geographic Information System models that he and his colleagues developed to identify places where highways pass through areas important for wildlife movement. By taking into consideration factors such as land cover, elevation, slope, and human population density, the models enable Singleton and his colleagues to identify places where wildlife-crossing structures should be considered to promote highway safety and help maintain healthy wildlife populations.

These crossings are physical structures, such as culverts and grass-covered bridges, that reroute animals, ranging from rodents and amphibians to wolverines and bears, across roadways. One area where Singleton has worked, and where crossing structures are currently under construction, is along Interstate 90 over Snoqualmie Pass in Washington State—a major, 24-kilometer-long east-west highway through the Cascade Mountain range that carries, on average, 27,000 vehicles a day.

Along with colleagues from Washington Department of Transportation, Washington Department of Fish and Wildlife, universities, tribal partners, and nonprofit organizations, Singleton is expanding his modeling efforts as part of the Washington Wildlife Habitat Connectivity Working Group. Singleton and his working group colleagues recently received the Federal Highway Administration's "2011 Environmental Excellence Award" for their statewide assessment of habitat connectivity in Washington. The results of this assessment (available online at http://www.waconnected.org) and other ongoing modeling efforts by Singleton and his colleagues are helping to keep highways safe for both people and animals.

identify and focus on those insects that are most likely to be effective. Because plant chemistry regulates plant–insect interactions (e.g., by determining how much of the plant insects eat), researchers can learn much by considering chemical ecology. Most of what scientists know about plant–insect chemical ecology comes from studying agricultural pests, but they have yet to apply this wealth of knowledge to the biocontrol of weeds. Forest Service scientists are studying chemical ecology regarding the biocontrol of weeds and discovering that biocontrol insects affect weed chemistry in very different ways. They are finding that leaf- and root-chewing biocontrol insects trigger weeds to produce huge amounts of defensive compounds, such as toxic chemicals in leaves, whereas galling insects, which cause and live within abnormal plant growths, have little effect on weed chemistry. Producing these defensive compounds proves costly for the weed because it requires resources the weed would otherwise use for growing and producing seeds. For example, in a study on the Gallatin National Forest in Montana, researchers applied a plant hormone to houndstongue plants to trick them into producing these chemicals in the absence of insects. These plants were consequently smaller and thus may not have survived the winter as successfully as unaffected plants. The importance of plant chemistry in successful biocontrol is becoming evident, and the emerging science on plant–insect chemical ecology should provide valuable information regarding what types of insects are most likely to affect weed populations, saving time and money and maximizing the success of this powerful management tool. More information is available by accessing http://www.fs.fed.us/rm/grassland-shrubland-desert/research/projects/integrating-chemical-biological/.

Lead: Rocky Mountain Research Station



▲ When tansy ragwort flea beetles feed on invasive tansy ragwort leaves, at least 11 defensive plant chemicals are triggered after only 4 days (each peak equals one chemical). These chemicals are costly for the plant to produce and likely contribute to the success of this biocontrol insect. *Justin Runyon, Forest Service*

▲ A caterpillar of the cinnabar moth serves as a biocontrol agent of invasive tansy ragwort. This insect induces large chemical changes in the host plant and has been used to dramatically reduce populations of this weed in the Northwestern United States. *Justin Runyon, Forest Service*

A Peek Inside Southern Pine Beetle's Gut

Scientists capture detailed images of the gut and its dangerous fungi cargo

A Forest Service scientist and his collaborators at Mississippi State University used advanced microscopy to examine in detail the southern pine beetle mycangia—the specialized body structures where the insects carry fungi that they use both to help kill trees and as a food source.

The southern pine beetle, *Dendroctonus frontalis*, is a small black beetle that is native to North and Central America. The beetles are smaller than a grain of rice, but in spite of their tiny size, are among the most destructive pests known to pine forests. The bug's range occurs from Pennsylvania to Texas and from New Mexico and Arizona to Honduras. Documented outbreaks of southern pine beetle are periodic, occurring in cycles at various locations. The beetle

will attack all species of pine but shows a strong preference for southern yellow pine species such as shortleaf, Virginia, and pitch pines. Adult beetles invade pine trees by boring through the bark to lay their eggs. The tiny white eggs hatch into larvae that develop into pupa. After pupation is complete, newly formed adults chew exit holes through the tree bark, take flight, and repeat the cycle of reproduction and infestation of pines. The winding, S-shaped egg galleries that develop eventually girdle the host tree and result in its death. Researchers believe that periods of drought and other factors that cause stress to pine trees contribute to southern pine beetle outbreaks.

The highly detailed images from advanced microscopy provide researchers with new insight to the interactions between bark beetles and their associated fungi. The knowledge is applicable to other bark beetle systems and can be used to devise new control strategies and identify new antibiotics. Research results were published in *Acta Zoologica*, a peer-reviewed journal. The results were made possible through a cooperative agreement awarded by the Forest Service's Southern Research Station to Mississippi State.

Lead: Southern Research Station

Nonnative Forest Pathogens Cost Homeowners Millions of Dollars Annually

Forest Service researchers find that programs to slow the spread of forest diseases provide important benefits in terms of reduced expenditures and losses

Nonnative forest pathogens kill many thousands of trees annually in the United States. Two serious fungal diseases are oak wilt in the East and sudden oak death (SOD) in the West. Information is limited on the economic costs and losses to landowners and municipalities from these diseases, especially for residential areas. Forest Service researchers predicted the spread of SOD in California and oak wilt in Anoka County, MN, over the decade 2010 to 2020 and then predicted annual expenditures for oak treatment, removal, and replanting and property value losses associated with tree mortality. For SOD in California, the researchers predicted that annual expenditures could reach almost $1 million and annual property value losses up to $13 million. For oak wilt in a single county in Minnesota, they predicted annual expenditures

Profile in Science—Mike Ryan

Senior-level scientist focuses on statistics and science synthesis

▲ Mike Ryan, Forest Service Scientist. *Forest Service*

Mike Ryan began his career with Research and Development at the Forest Service in 1979, when he was hired as a statistician for the agency's Rocky Mountain Research Station, working on data analysis for the Beaver Creek Project in Flagstaff, AZ. The project looked at ways to increase flow in mountain streams through vegetation management.

Since then, Ryan has moved beyond statistics and today studies the carbon impacts of increases in fire frequency. Ryan's research has shown that if the climate changes as currently predicted, fire frequency will increase from the historical 150 to 300 years to less than 30 years.

Ryan was recently appointed as a senior-level scientist; only 19 of 482 Forest Service scientists have attained senior level. Ryan's last research review panel recommended the promotion for substantial contributions toward understanding the decline in tree and forest productivity with stand age, the role of tree and ecosystem respiration in understanding plant and ecosystem carbon balance, and the role of disturbance in regulating landscape carbon balance. The panel also recognized Ryan's role in leading efforts to synthesize science important to the Forest Service: "A synthesis on climate change impacts on U.S. forests and arid lands" for the U.S. Climate Change Research Program and "A synthesis of the science on forests and carbon for U.S. forests" for the Forest Service Global Change Research Program.

Ryan remembers what encouraged him to work with trees. "I became interested in the effects of environment and tree age on tree growth during my Ph.D. at Oregon State," Ryan said. "During my post-doc at The Ecosystems Center in Woods Hole [MA], I was introduced to the problems of climate change."

Ryan's work on these issues has led him to conduct research in Yellowstone National Park, Costa Rica, Brazil, Australia, New Zealand, Sweden, Colorado, Wyoming, and Canada for the National Aeronautics and Space Administration's BOREAS Project.

Although his extensive research and accomplishments have been recognized, Ryan is not done yet.

"My goal is to work on some of the fundamental unknowns about how trees work, so we can predict how they will respond to the coming environmental stressors, like drought and warmer temperatures."

▲ Oak wilt pocket next to house. *Joe O'Brien, Forest Service*

of $2 to $6 million. Although the predicted amounts are substantial, they are nevertheless lower bounds on total economic losses because of reduced ecosystem services, such as water quality, and increased safety hazards. Quantifying expenditures and losses to landowners is critical to strategies for prevention, management, and research of diseases and pests in forests. Research partners include University of Minnesota; University of North Carolina, Charlotte; Cambridge University, United Kingdom; and University of Nevada–Reno.

Lead: Northern Research Station

A Newly Discovered Pheromone Can Detect the Insect Vector of Thousand Cankers Disease of Walnut

Early detection enables rapid response to this destructive pest

Scientists can use a male-produced pheromone from the walnut twig beetle to detect populations of the beetle, vector of thousand cankers disease of walnut trees. The beetle threatens both the California orchard industry and extensive stands of black walnut timber, valued at more than $500 billion, in the Eastern United States. A team led by Forest Service scientist Steve Seybold filed a provisional patent application in mid-July 2011 for the discovery of the attractant pheromone and for several behavioral chemicals that appear to deter the beetle from flying and landing. A key element in the success of the project was the capability of raising live beetles at the Pacific Southwest Research Station's insect rearing facility in Davis, CA, and then using the live beetles in laboratory research to trap the potential behavioral chemicals from the headspace around infested walnut branches. The technology was demonstrated in Tennessee, Utah, and Virginia in July and August 2011. Early results suggest that the bait will detect the beetle in these areas of intermediate- and low-population density. Research partners included Simon Fraser University, Department of Biological Sciences, Burnaby, British Columbia, Canada; Tennessee Department of Agriculture; University of California, Davis, Department of Entomology; USDA Animal and Plant Health Inspection Service; and USDA National Institute of Food and Agriculture. For more information on thousand cankers disease, please refer to the Pest Alert at http://na.fs.fed.us/pubs/palerts/cankers_disease/thousand_cankers_disease_low_res.pdf.

Lead: Pacific Southwest Research Station

▲ Ed Pigeon pounding a log. *Therese Poland, Forest Service*

Reducing Negative Cultural Effects of Emerald Ash Borer

Forest Service professionals collaborate to save black ash wood for Native American basketmakers

Black ash has great cultural and economic importance in the Northeastern United States, especially for Native Americans. The widespread destruction and removal of black ash in response to an emerald ash borer (EAB) find are painful prospects for tribes and basketmakers. An innovative collaboration combining traditional knowledge with scientific expertise has found that a traditional practice offers a reasonable solution for those who depend on black ash splints. Historically, black ash has sometimes been submerged in

water for later use in basketmaking. In a recently completed study, a Forest Service entomologist working with a Forest Service geographer demonstrated that sinking black ash logs in running water for 2 to 3 months in the spring kills EAB larvae and preserves the wood qualities necessary for basketmaking. The scientists worked with a family of basketmakers from the Gun Lake Tribe throughout the research. Additional studies will evaluate submersion during winter months and the effects of longer term underwater storage on basket-splint quality and color.

Lead: Northern Research Station

The Forest Health Initiative

New partnership seeks biotechnology solutions for improving forest health

The Forest Health Initiative is a new concept for addressing emerging forest diseases and pests with genetics and, in particular, biotechnology. The idea is to develop a focused, integrated science strategy to identify resistance genes to specific tree diseases and transfer them into the susceptible tree species, while at the same time developing the social, environmental, and regulatory side of the equation. In cooperation with University of Georgia, State University of New York–Syracuse, Penn State University, Clemson University, and the American Chestnut Foundation, Forest Service scientists are using American chestnut, which was extirpated in its native range by chestnut blight, as a test case. This is hardly an emerging problem, but it is one that can still benefit from modern biotechnology and genomic approaches. To move toward a blight-resistant American chestnut, the Initiative is mapping and sequencing the Chinese chestnut genome in an effort to find resistance genes. Once identified, these genes are cloned and transformed into American chestnut cell cultures that are later induced into seedlings.

▲ Early disease resistance tests help keep forests healthy and resilient. *Forest Service*

During these early stages, scientists evaluate the transformed materials for resistance using a series of tests that range from molecular assays to field tests using artificial inoculations of the blight fungus. The American chestnut project is now entering its third year, with more than 40 candidate genes identified and 20 of these transformed into American chestnut. Early disease resistance tests will be ongoing this year. In addition, social, environmental, and regulatory groups are progressing on the social science front by engaging conservation constituents and developing a thorough understanding of the issues around deploying genetically modified forest trees.

Lead: Southern Research Station

Native Mosses and Liverworts Thrive in Secondary Forests

Novel forests emerge in abandoned agricultural fields to foster desirable plants

In Puerto Rico, the African tulip tree (*Spathodea campanulata*), an introduced species, dominates many secondary forests—forests or woodlands that have regrown after a major disturbance, such as fire, insect infestation, or timber harvest. These novel forests emerged after farmers abandoned agricultural fields in the mid-20th century. The International Institute of Tropical Forestry and University of Puerto Rico wanted to know the ecological function of these forests. The researchers' goal was to determine if the emerging forests fostered establishment of nonvascular

▲ Mervin Pérez, graduate student at University of Puerto Rico, Mayagüez Campus, downloading environmental data from data loggers to laptop computer. Data loggers were placed on tree trunks of *Spathodea campanulata*. *Jaffet Santiago, Biology Department, Mayagüez Campus, University of Puerto Rico (used with permission)*

Invasive Species

▲ The moss, *Neckeropsis disticha*, was the most common bryophyte on African tulip tree trunks on kartz topography. This moss forms mats that provide habitat for microorganisms and plants. *Frank Suárez, Biology Department, Mayagüez Campus, University of Puerto Rico (used with permission)*

▲ African tulip trees, on kartz topography, showing more abundant bryophyte cover at the bases of their tree trunks. *Frank Suárez, Biology Department, Mayagüez Campus, University of Puerto Rico (used with permission)*

epiphytic plants such as mosses and liverworts. These important plants regulate short-term fluxes in the water cycle, provide habitat to wildlife, and serve as germination sites for seeds of other plants, like orchids. The researchers inventoried moss and liverwort communities within *Spathodea* forests that emerged on abandoned sugarcane fields and fruit tree and coffee plantations. The inventories revealed 57 mosses and liverwort species. The researchers observed the highest richness of mosses and liverworts on *Spathodea* forests that emerged from abandoned fruit and coffee plantations on karst topography. Abandoned sugarcane fields on alluvial plains had the lowest diversity. Overall, *Spathodea* patches were similar in moss and liverwort diversity to mature native forests on the island, suggesting that these forests, although dominated by an introduced species, can provide the ecological characteristics necessary to support native nonvascular plant communities. In summary, although the African tulip tree is considered to be an invasive species, African tulip-dominated forests have conservation value because they promote the succession of epiphytes by giving them a suitable habitat.

Lead: International Institute of Tropical Forestry

Science Solution

Broken Bat Incidents Down by Half in Major League Baseball

Safety of players and fans increases thanks to practical science

The Forest Service is working with Major League Baseball to help make America's pastime safer, and the results so far have been impressive.

"Since Major League Baseball's partnership with the USDA Forest Service began in 2008, we have witnessed a dramatic decrease in the number of broken bats, thanks to the extensive efforts of the scientists from the Forest Products Laboratory, especially Dave Kretschmann," said Dan Halem, Major League Baseball's Senior Vice President of Labor Relations.

In fact, thanks to Kretschmann's research, multiple-piece failure rates in baseball bats have dropped by 50 percent in the past three seasons.

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▲ Frequency of bats breaking into multiple pieces was primarily because of slope of grain issues, not necessarily the species of wood. *MLB Advanced Media (used with permission)*

Kretschmann, a research engineer at the Forest Products Laboratory in Madison, WI, has seen video of every shattered bat, tested and analyzed hundreds of bats, and recorded the "who, when, and how" of every breakage in 2009, 2010, and through the early parts of the 2011 season. Through his recommendations and the cooperative work of TECO (an independent certification and testing agency for wood products), baseball players, owners, and fans have reaped the rewards of increased safety through practical science.

"Most of my initial recommendations addressed 'slope of grain' issues," Kretschmann said. Slope of grain refers to the straightness of the wood grain along the length of a bat. Straighter grain lengthwise

▲ Bats were not only breaking, they were shattering. Players, coaches, and fans have all sustained injuries due to "multiple-piece failure" breakage. *TECO (used with permission)*

is associated with less likelihood for breakage. "One change made to address this issue, something that players and fans can easily see," says Kretschmann, "is a small ink dot placed on the face grain of bat handles. This helps identify grain characteristics at just a glance."

Although broken bats have always been part of the game, multiple-piece failure is something relatively new. With recent changes in bat geometry, the wood species used to manufacture bats, and inconsistencies in the grain of the wood itself, up until 2008, an increase occurred, not only in bats cracking or breaking but also in bats dangerously shattering into multiple pieces on contact.

One particular modern bat design feature, a thick barrel tapering quickly to a much thinner handle, is also associated with increased multiple-piece failure, Kretschmann said. All Major League Baseball bats need to weigh about the same, so a bat using a larger volume of wood needs to use lower density wood, which is also weaker. Overdrying during the production process can create weaknesses and affect a bat's strength integrity, too. Thanks to these findings, the 2010 season saw limits to bat geometry dimensions, wood density restrictions, and wood drying recommendations. Shattered bat incidents continued to decrease under these new limits, and the trend continued into the early parts of the 2011 season.

"We will continue to work closely with the Forest Products Laboratory and the bat manufacturers to further decrease the number of broken bats in order to ensure the safety of all on-field personnel and our fans," Halem said.

Outdoor Recreation

The **Outdoor Recreation** SPA is directed at understanding and managing outdoor environments, activities, and experiences that connect people with the natural world. Research within this SPA develops the knowledge and tools to support informed recreation and wilderness management decisions that improve outdoor recreation opportunities for current and future generations while sustaining healthy ecosystems.

Culturally Appropriate Conservation Education for the Hmong-American Community

A new DVD puts a modern twist on traditional Hmong storytelling, delivering key messages in entertaining and educational segments covering a wide range of topics

Connecting ethnic minority communities with nature and nature-based activities is challenging, especially when conservation professionals and educators lack culturally appropriate materials and outreach tools. A Forest Service scientist, working with academics, Hmong natural resources professionals, and the Hmong arts and theater community, developed a DVD—*The Wildlife and Wilderness Exploration Show*—in a modern twist on traditional Hmong storytelling with English subtitles. The educational messages cover topics such as using public land, regulations and safety, fire prevention, gathering wild plants, and the concept of "leave no trace." In contemporary Hmong-American culture, DVDs are a popular form of entertainment and cultural learning, particularly appropriate for new refugees and elders with little proficiency in English. Research partners include Digital Motion LLC, St. Paul, MN; University of Minnesota, St. Paul, Bioproducts and Biosystems Engineering; Hmong Arts Connection, St. Paul, MN; and Minnesota Department of Natural Resources, Fort Snelling State Park.

Lead: Northern Research Station

▲ Face of the *The Wildlife and Wilderness Exploration Show* DVD. *Forest Service*

Moving Field Guides: Learning Ecology Through Dance

Children in Baltimore turn their observations into movements as they learn about the environment

Children use all of their senses when exploring the outdoors, a crucial first step on the road to inquiry and an understanding of the environment. Through a partnership with a professional dance company, a Forest Service scientist,

▲ Students and dancers performing a "Moving Field Guide" in Patterson Park, Baltimore, MD. *Steward Pickett, Baltimore Ecosystem Study LTER, Cary Institute of Ecosystem Studies (used with permission)*

Outdoor Recreation

▲ Dr. Mark Twery, Northern Research Station, describing the structure of a dandelion stem to participants in the "Moving Field Guide" workshop at Patterson Park, Baltimore, MD. *Steward Pickett, Baltimore Ecosystem Study LTER, Cary Institute of Ecosystem Studies (used with permission)*

and a local environmental educator, Baltimore, MD, children turned their observations of nature into movement as they learned about the environment. The Forest Service scientist led discussions of local ecology in a neighborhood park in Baltimore. The students and dancers created movements to express what they learned, which they combined into a "Moving Field Guide," a dance representing natural events, which included bark sloughing off a tree trunk, wind blowing winged seeds to new homes, ducks migrating, and reactions to a skunk. These dances are shared through community performances and videos as encouragement to other children and parents to notice the intricacies of nature and to find ways to make those observations personal and enduring. Additional funding provided by the Washington Office Conservation Education program will extend the Moving Field Guide experience to Girl Scouts of the Nation's Capital in 2012. Partners in this program include the Dance Exchange, Baltimore Ecosystem Study, University of Maryland, and Maryland Institute College of Art.

Lead: Northern Research Station

Profile in Science—*Jeremy Pinto*

Native American scientist studies "outplanting" of native plants

▲ Jeremy Pinto, Forest Service Plant Physiologist. *Forest Service*

To say Jeremy Pinto has a green thumb would be an understatement.

A research plant physiologist at the Forest Service Rocky Mountain Research Station, Pinto received his bachelor's degree in biology in 1999 and then finished his graduate career with a Ph.D. in natural resources in 2010. In his current research position with the Forest Service, Pinto examines and improves native plant nursery cultural practices, investigates subsequent consequences of cultural practices on seedling physiology, and studies the biophysical site limitations of outplanting—the planting of seedlings raised in a greenhouse or nursery planting bed into the field.

"My interest in the natural world came from my father, a now-retired high school biology teacher," Pinto said. "Throughout school, I pursued the biological and natural sciences while picking up seasonal work with the Forest Service."

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Resource Management and Use

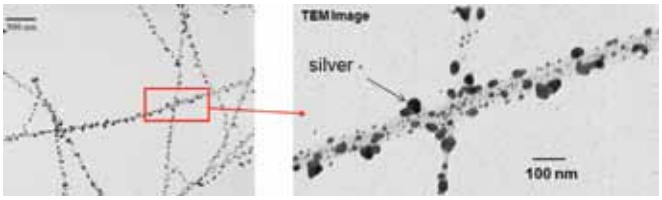
The **Resource Management and Use** SPA provides a scientific and technological base to sustainably manage and use forest resources and forest fiber-based products. Research areas include plant science, soil science, social science, silviculture, productivity, forest and range ecology and management, forest harvesting and operations, forest and biomass products and utilization, economics, urban forestry, and climate change.

Novel Templates Developed for the Synthesis of Nanostructures

New technology has the potential to benefit cellulose-based industries, such as paper and textiles, and also has potential applications for sensors and energy storage capabilities

Harvesting the properties of widely available natural biopolymers for the design of novel systems in nanobiotechnology has been largely ignored in favor of other biological molecules, such as proteins, viruses, or DNA. A joint research effort between the Forest Products Laboratory and Purdue University has shown that cellulose nanocrystals (CNCs) have the capacity to assist in the synthesis of metallic and semiconducting nanoparticle chains. The researchers synthesized silver, gold, copper, platinum, cadmium sulfide, and zinc sulfide nanoparticles on CNCs and could control the nanoparticle density and particle size. CNCs are rod-like reinforcement materials that can be extracted from trees, plants, and some sea animals (sea squirts). This new technology will potentially benefit a variety of cellulose-based industries (e.g., paper, packaging, textile) and has potential applications for sensors, catalysts, antimicrobial materials, current carrying, and energy storage.

Lead: Forest Products Laboratory



▲ Transmission electron microscopy (TEM) images of the formation of silver nanoparticles on the surface of tunicate CNCs. *Robert Moon, Forest Service*

Visualizing Storage of Harvested and Burned Forests

A new process visualizes how harvested and burned stands contribute to overall carbon storage over different time scales

Interest is growing in documenting the capacity of forest ecosystems to sequester atmospheric carbon and mitigate climate change. New research at the Forest Service's Rocky Mountain Research Station has resulted in a process to visualize how harvested and burned stands contribute to overall carbon storage over different time scales. Called ForCaMF (Forest Carbon Management Framework), this framework applies a stand-level forest carbon simulation tool—the Forest Vegetation Simulator—spatially across vegetation and disturbance history maps. Montana piloted ForCaMF, and the Northern Rocky Mountain Region of the NFS is currently implementing it as part of a project supported in part by the

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Pinto maintains a connection to his Native American background by working as a technical bursary liaison to indigenous peoples across the United States.

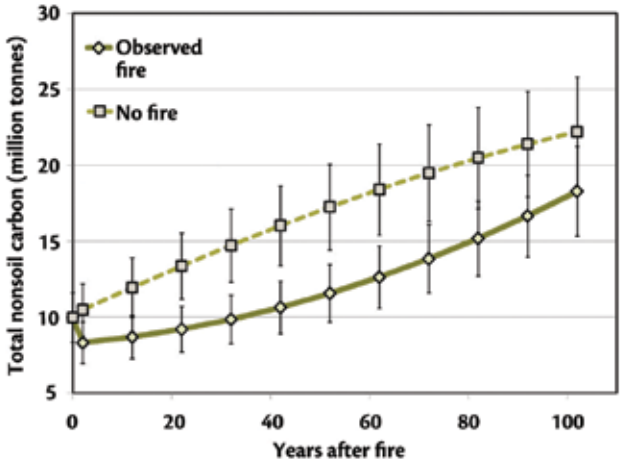
"Today, those interests seeded by my father have not only taken root, developed, and matured but are continuously growing through my current research interests, which include forest and native plant nursery propagation, outplanting, and establishment, including biophysical and physiological limitations and adaptations within each system," Pinto said.

His research is as timely as it is important because population pressure and the accompanying development of urban and rural infrastructure are threatening landscapes around the globe.

"Within these disturbed areas, it is important to understand how to quickly repair and restore valuable ecosystem services and production," Pinto said. "Restoration and reforestation using nursery-produced seedlings are often the most reliable way to ensure successful establishment and rapid growth following outplanting."

National Aeronautics and Space Administration. More information will be available in an upcoming station publication, *Forest Carbon Decision Support Through Probabilistic Interpretation of Widely Available Monitoring Data*.

Lead: Rocky Mountain Research Station



▲ ForCaMF output showing nonsoil carbon storage in all forests burned in Ravalli County, MT, between 1999 and 2001. The 100-year projected carbon storage following observed fire patterns and intensities (blue) is contrasted with storage associated with the same stands if no fire had occurred (green). Error bars represent the standard deviation of 2,000 simulations. *Sean Healey, Forest Service*

A Case Study of Biocomplexity in Arctic Ecosystems

Integrating research, education, and traditional knowledge in ecology

Integrating research and education is a fundamental goal of institutions and agencies supporting science, because society benefits from a more informed and scientifically literate population. The value of integrating traditional ecological knowledge in research has been demonstrated in several ecosystems, yet specific approaches and achievements of efforts integrating research and education are not widely published in environmental research journals. One way to address the imbalance between efforts devoted to broader effects and avenues for reporting on these efforts is the publication of case studies and assessments of integration efforts in journals that reach a research audience as opposed to an education audience. In that spirit, the study *Biocomplexity of Arctic Tundra Ecosystems* integrates an interdisciplinary research project investigating the interactions of climate, vegetation, and permafrost with a university field course, Arctic Field Ecology, and with indigenous Inuit students and elders. The integration enabled university students and native community members, drawn by the opportunity to gain education and experience, to participate with the research team. This participation has had synergistic benefits with the research agenda and diversified the pool of stakeholders involved in the research. The educational component provided a wider degree of participation in the biocomplexity study than would have occurred otherwise and enhanced the research output of the study through the efforts of students and instructors. Half of the participants in what was primarily a research effort received educational benefits. The long-term effects of a more diverse research team are less tangible but, we hope, positive in terms of broader effects. Research partners include University of Alaska and University of Minnesota.

Lead: International Institute of Tropical Forestry

▲ The arctic field ecology youth-elder-science camp involved such diverse activities as (a) stretching hides of caribou recently harvested by the elders and (b) observing microscopic soil invertebrates. *William A. Gould and Grizelle González, Forest Service*

Cascade Volcanoes May Be at Greater Risk for Debris Flows As Climate Warms

On the steep flanks of the volcano, retreating glaciers expose loose sediment that can form destructive debris flows during intense rainstorms

One of the most visible effects of climate warming in the Pacific Northwest is the retreat of glaciers located on the flanks of volcanoes in the Cascade Range. As glaciers retreat, they expose steep, unconsolidated sediment that is prone to

▲ Retreating glaciers leave loose sediment exposed, increasing risk of large debris flows following heavy rain. *Gordon Grant, Forest Service*

gullying and may fail catastrophically during intense rainstorms, resulting in debris flows. These flows can travel downslope for many miles at great speeds, with enormous destructive potential. Such was the case in November 2006, when a record rainstorm initiated multiple debris flows on all major volcanoes in the northern Cascades. These flows destroyed roads and bridges and resulted in the unprecedented closure of Mount Rainier National Park for more than 6 months.

Scientists with the Pacific Northwest Research Station, in cooperation with Oregon State University, Mount Rainier National Park, U.S. Geological Survey, and the National Science Foundation, studied how, where, and under what circumstances such debris flows initiate. They discovered previously unreported links between receding glaciers, areas of stagnant and debris-mantled ice, and initiation zones for debris flows. These findings are helping the Forest Service and National Park Service reassess the risk to downstream infrastructure from such events and provide a potentially important example of how climate warming may be affecting mountain environments. These studies also are being coupled with downstream work by the U.S. Geological Survey to help explain changing patterns of channel aggradation and increased flooding potential for lowland areas surrounding Cascade volcanoes. The *Christian Science Monitor* and *Los Angeles Times* reported on these findings.

Lead: Pacific Northwest Research Station

In Puerto Rico, Multiple Hurricanes Promote Growth of Dominant Ferns and Vines

A study contrasts sharply with evidence about tree communities

Hurricane disturbance caused pronounced and persistent changes in the nontree species composition of a subtropical wet forest in Puerto Rico. A unique long-term Forest Service data set tracked the response and recovery of tropical forest herb, shrub, and vine communities to multiple hurricanes over 21 years on the Bisley Experimental Watersheds on the Luquillo Experimental Forest. Analysis by Forest Service scientists found that hurricanes had altered nontree community species composition by promoting the dominance of rapidly spreading ferns and vines. These findings contrast sharply with other evidence, showing that hurricane effects on the tree community are often negligible over similar timeframes. These findings are particularly significant because nontree species comprise the bulk of forest vascular plant diversity.

Lead: Northern Research Station

▲ Various fern species growing on the Bisley Experimental Watersheds are important to forest succession in the Luquillo Experimental Forest. *Omar Perez Reyes, PhD- Candidate, College of Natural Resouces, Utah State University (used with permission)*

Researchers Study the Accuracy of Using Small Specimens in Testing New Wood Products

Research shows the need for more testing before scientists can be confident that results from accelerated methods reflect the durability of commercial wood products

The development of improved durable wood products involves years of testing to ensure long-term durability. The

most rigorous and meaningful evaluations place test specimens, usually stakes, in soil contact in humid climates and may require many years to yield meaningful results. Recently, researchers have turned to using smaller specimens in an attempt to accelerate these stake tests. It is widely accepted that these smaller specimens provide meaningful results several times faster than the lumber specimens traditionally used in stake tests. Although the smaller specimens generally fail more quickly than larger specimens, it is unclear how their durability relates to much larger commercial wood products. Scientists from the Forest Service and Mississippi State University are beginning to provide answers to this question with research in field plots at Harrison Experimental Forest in Saucier, MS. Scientists compared the durability of small specimens with that of matched larger lumber specimens for 64 treatment groups. This comparison revealed that, although smaller specimens showed obvious evidence of decay 2.1 times sooner than the lumber specimens, this relationship varied greatly. In some cases, the smaller specimens provided little or no acceleration. Scientists noted a similar trend when comparing time to failure for the two specimen sizes. The results indicate substantial uncertainty in using small specimens to predict the durability of larger specimens or commercial wood products. Further research is underway to develop models that better define the relationship between accelerated stake test results and the durability of commercial products.

Lead: Forest Products Laboratory

▲ Stake plots in the Harrison Experimental Forest, Saucier, MS, provide data to evaluate the durability of wood products. *Stan Lebow, Forest Service*

Science Solution

Rocky Mountain Center for Fire-Weather Intelligence Saves Lives, Property, and Resources

Experts look to center for real-time information on combating wildfires, predicting smoke impacts, planning prescribed burns

▲ Chuck Maxwell, Meteorologist. *Forest Service*

The Rocky Mountain Center for Fire-Weather Intelligence was established in 2001 at the Forest Service Rocky Mountain Research Station to bridge the gap between state-of-the-art research in fire meteorology and the operational forecasting of fire weather and fire danger.

The center delivers a plethora of value-added fire-weather intelligence products that provide real-time critical support to fire- and air-quality managers across the country. The center also generates more than 200,000 maps, graphs, and charts on current and future (up to 75 hours in advance) fire-weather conditions at high spatial and temporal resolution over the entire continental United States. The center updates all products twice a day and delivers them through the Web in real time at http://fireweather.info.

A number of Web-based applications enable users to filter and view pertinent fire-weather information in ways that facilitate their decisionmaking process. The center has more than 1,300 registered professional users who rely on its products to plan prescribed burns, assess local and regional fire danger, predict smoke impact from ongoing fires, or develop short-term action plans for combating wildfires.

Investigators have also employed the Rocky Mountain Center's weather products in the investigation of several fire-related accidents and fatalities, as well as in post-factum analysis of conditions that led to loss of property due to fire. The high operational value of the center's products and decision-support tools is evident from user testimonies.

"We use the center's high-resolution weather modeling products on an almost daily basis during our operational fire season to assist in the creation of decision support products," reports Chuck Maxwell, lead predictive services meteorologist at the Southwest Coordination Center. "RMC has been shown to be an invaluable resource to ourselves and to those we serve in the fire management community."

The center is part of the agencywide Fire Consortia for Advanced Modeling of Meteorology and Smoke and the only fully operational center.

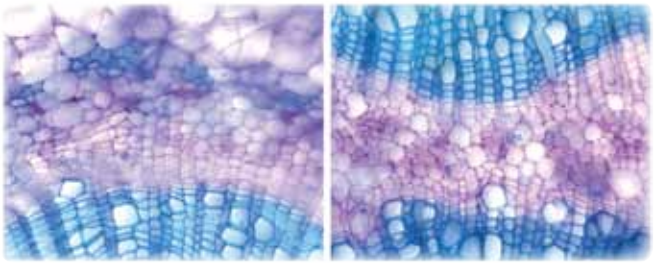
Resource Management and Use

Scientists Identify Genetic Factors That Regulate Growth of Tree Bark and Wood Tissues

Genes provide specific targets for tailoring woody growth for applications, including bioenergy feedstocks

The stems of forest trees contain a layer of dividing cells called the vascular cambium. These cells ultimately differentiate into either bark or wood tissues and, over time, are responsible for the radial growth of the stem. Using genomics-based technologies, Forest Service researchers, in cooperation with University of California, Davis, identified and characterized genes regulating specific aspects of stem growth in poplar trees. The study showed one gene, named popREVOLUTA, controlled the formation of the cambium and the patterning of the woody tissues derived from the cambium. It showed a related gene, popCORONA, regulated how the cells derived from the cambium differentiate. Together, these genes give fundamental insights into how the woody growth of tree stems is regulated and provide specific targets for tailoring woody growth for applications, including bioenergy feedstocks.

Lead: Pacific Southwest Research Station



▲ Tree stems normally make a single layer of wood (blue cells, bottom left). Changing expression of a single regulatory gene results in the formation of a second wood-forming layer (right). *Dr. Juan Du, Forest Service*

Producing Biochar From Forest Biomass

Dead wood in U.S. forests can be a component in making charcoal, synthetic gas, and even fuel for vehicles

National forests in the West are overgrown and vulnerable to catastrophic wildfires and attacks by insects and disease. Drought and conditions associated with climate change exacerbate the problem and further contribute to deteriorating forest health. Treatments to thin the forests, decrease fuel loads, and clear out insect- and disease-killed trees have proven expensive. Because there are few markets for small roundwood and virtually no markets for residual material such as tops and limbs, potential bidders judge many timber sales to be economically infeasible. When treatment projects do get carried out, slash piles of residual material are often burned onsite, contributing to smoke, air pollution, and greenhouse gas emissions. The use of woody biomass to produce value-added products, especially from residual materials of biomass removal and wood processing, enhances the feasibility of biomass removal and thus of forest treatment projects. One way to convert woody biomass into a useable material is through pyrolysis, a process that heats organic matter rapidly to high temperatures with limited or no oxygen. Products from woody biomass include (1) biochar (biological charcoal), which has potential as a solid fuel, a soil amendment, and a precursor for secondary carbon products, including activated carbon; (2) syngas (synthesis gas), which has potential for energy production and as feedstock for liquid fuels and chemical production; and (3) bio-oil, which has potential for use as heating oil, transportation fuel, or chemical feedstock. Research at the Rocky Mountain Research Station has focused primarily on biochar. Several potential applications, and thus markets, for biochar exist. As a soil amendment, biochar attracts and holds water, increases ion exchange capacity, makes the soil more porous, and enhances sorption of organic compounds. Such properties enhance soil productivity and facilitate plant growth to reduce erosion and restore compacted, oxidized, and degraded soils. Research also points to horticultural and nursery applications, such as using biochar as a substitute for vermiculite in plant-growing media and enhancing nursery media properties, akin to biochar's potential as a soil amendment. Moreover, biochar is a stable form of carbon that is highly resistant to further decay and remains in the soil for hundreds or thousands of years, implying uses for carbon sequestration. As a precursor to activated carbon, biochar has the potential for use in filters, such as those used in water treatment facilities, and well-established markets exist for activated carbon. Station scientists in Fort Collins, CO, Missoula, MT, and Moscow, ID, along with university and industry

▲ The beetle-killed to biochar process. *Dan McCollum, Forest Service*

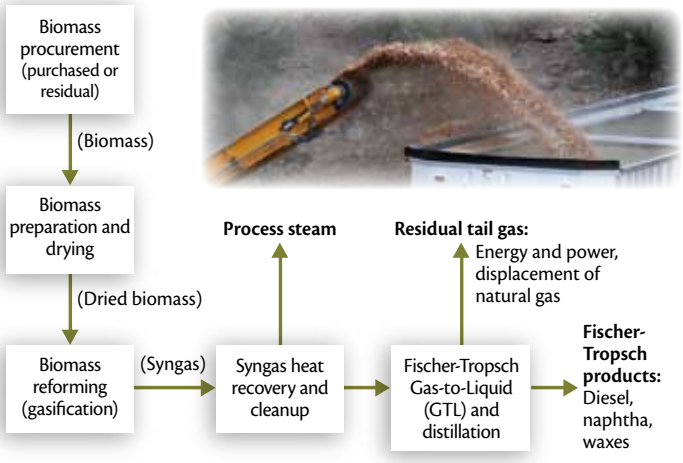
cooperators around the country, are conducting ongoing research in these areas, including soil test plots under a variety of conditions. One important outcome is the dialogue the research has fostered among researchers, industry, and communities. A recent symposium in St. Regis, MT, held panel discussions on a range of topics, including forest restoration, conversion of biomass to biochar, emerging uses for biochar, as well as on information gaps, challenges, and next steps.

Lead: Rocky Mountain Research Station

Researchers Conduct Engineering and Economic Modeling of Biofuels Production

Model helps to highlight the engineering and financial assumptions that will be critical to the project's success

Biomass, including overstocked and deadwood biomass from forest lands, can produce energy that directly replaces fossil fuels and liquid fuels from food crops, thus simultaneously improving the Nation's energy balance, food security, and forest health. One way to achieve this is through a thermochemical refining method called biomass gasification. Gasified biomass can be burned directly to replace natural gas, or it can be cleaned and refined to produce Fischer–Tropsch biofuels, including low-sulfur diesel and other synthetic hydrocarbons. Locating a gasifier at a pulp mill enables existing infrastructure to handle and transport the biomass and byproduct heat to supply steam and energy for the pulp mill. Forest Product Laboratory researchers constructed a spreadsheet-based computer model to aid in the preliminary evaluation of the engineering and economic feasibility of such integrated systems. Researchers can easily modify this model to consider different scales, engineering configurations, end products, and financial parameters, thus providing a way to explore a number of options easily. If preliminary results seem promising, subsequent development and investment decisions will require much greater due diligence and more sophisticated engineering. Results show that such systems may be worth considering, depending on biomass costs, energy values, and capital equipment and operating costs. This research is being conducted in cooperation with ThermoChem Recovery International, Inc.; Flambeau River Biofuels LLC; Emerging Fuels Technologies; U.S. Department of Energy, National Renewable Energy Laboratory; and University of Wisconsin–Madison



▲ Process elements for the biomass gasification concept that are incorporated in the spreadsheet model. *Edward M. (Ted) Bilek, Forest Service*

Lead: Forest Products Laboratory

Forest Conservation in Africa

Local communities given incentives to protect and conserve forests

Forest Service researchers, funded by the U.S. Agency for International Development (USAID), worked in Ghana to develop a community-based carbon monitoring program that will help protect the restoration forests planted there 10 years ago, after extensive logging and grazing degraded the country's forest reserves.

The premise of the pilot study is to give local communities incentives to protect and conserve forests. Forest "fringe communities" received short- and long-term benefits to restore and conserve forests: legal access to farm forest land for 2 to 3 years by intercropping; labor payments to plant trees; and a promise of 40 percent of timber revenues when the trees were harvested.

Forest Service researchers have identified and trained interested individuals whose conservation work meets established quality control standards. The ongoing effort in Ghana is considered a successful pilot project and has raised recognition globally about the benefits of community-level forest management and monitoring; the researchers are expanding their efforts into other African countries.

Citizen science and participatory management are gaining widespread recognition, and the lessons learned in this work are widely applicable in both developing and developed countries, according to John Stanturf, the Forest Service researcher who led the effort in Ghana. "Countries like Ghana are learning the measuring, reporting, and verification tasks that are an important component of the REDD [Reducing Emissions from Deforestation and Forest Degradation] program so they will be able to receive payments for ecosystems services once the program is up and running," Stanturf said. He and his colleagues are working to secure payments to Ghana from REDD, which is supported by the United Nations and the World Bank. "There is a lot of administrative and political change that must occur before anyone is

willing to start paying for carbon." In addition to making payments to local communities in lieu of logging income, REDD also plans to augment Government agencies that are often under-resourced in Africa.

Internally, Stanturf and his fellow researchers at the Forest Service's Southern Research Station work in partnership with the agency's International Programs Office, whose mission is to mobilize technical expertise in support of the U.S. Department of State and USAID programs in natural resources management, including climate-related programs. Because U.S. tax dollars, as well as private sector funds, eventually will flow to programs such as REDD, it is in the Nation's best interest to ensure the countries that ultimately receive payments have citizens with adequate education and training to fulfill their end of the contract.

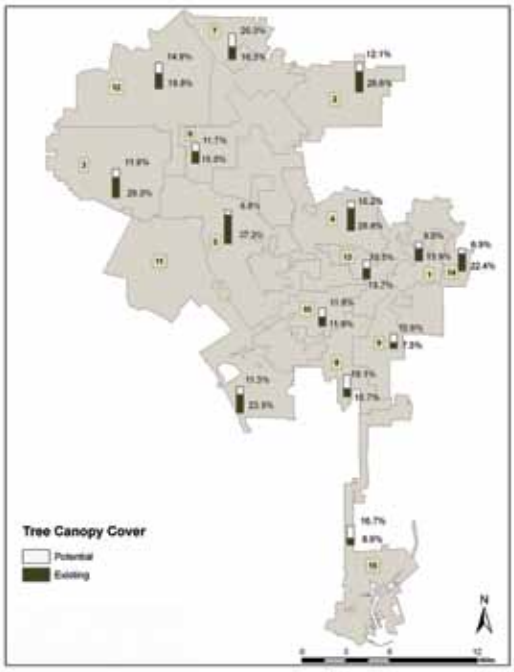
Research partners included Forest Research Institute of Ghana and Copperbelt University, Zambia. An overview of the pilot study was published in *Nature e Faune* (http://www.treesearch.fs.fed.us/pubs/38409).

Lead: Southern Research Station

Forest Service Science Informs Los Angeles Strategic Tree Planting Campaign

Mayor Villaraigosa calls Forest Service scientists for guidance in planting a million trees

The day after Antonio Villaraigosa was elected mayor of the city of Los Angeles (LA), he planted a tree and announced his plan to plant a million trees over the next several years. To guide this initiative, he called on Pacific Southwest Research Station scientists to answer some questions: "How green is Los Angeles today?" "Is there room for a million trees?" "Where should we plant them?" "What environmental and other benefits will our trees provide?" Using Geographic Information Systems, satellite images of the city, and numerical models, the Forest Service team—in cooperation with Los Angeles Conservation Corp; TreePeople; University of California, Davis, Department of Land, Air, and Water Resources; Los Angeles Department of Water and Power; and City of Los Angeles—answered these questions. In Los Angeles, the current urban forest covers 21 percent of the city and consists of about 11 million trees. Researchers developed an innovative program to determine the number of potential tree planting sites by "training" a computer to follow a series of decision rules. This virtual tree-site detector found 2.5 million potential sites. The city had plenty of room for a million new trees. Using research and models developed by Pacific Southwest Research Station scientists, the team estimated the value, over a 35-year period, from a million trees in Los Angeles at $1.3 to $2.0 billion. Average annual benefits were $49 to $60 per planted tree. For example, by storing carbon as biomass, a million new trees will reduce carbon dioxide in the air by about a million tons. This reduction is equivalent to removing 7,000 cars from streets and highways each year.



▲ Existing and potential tree canopy cover percentages for Los Angeles by Council District. *Greg McPherson, Forest Service*

▲ Canary Island palms at sunset. *George Gonzalez, Bureau of Street Services, City of Los Angeles (used with permission)*

Million Trees LA has planted more than 300,000 trees to date, and Pacific Southwest Research Station tree canopy cover maps have helped the program target trees for

Profile in Science—Dana Nelson

The path of a geneticist—from corn tassels to American chestnuts

▲ Dana Nelson, Forest Service Geneticist. *Forest Service*

Dana Nelson is a research geneticist and project leader with the Forest Service Southern Research Station. Based at the station's Southern Institute of Forest Genetics near Gulfport/Biloxi, MS, his interest in science began as a youngster during and between rounds of golf. The course was on a State park with a lake in north-central Iowa, with plenty of water and all the stuff that lived in it. On nearby private land were corn and soy fields everywhere.

"While I was still in high school, I worked a couple of summers detasseling corn to make hybrid seed, and plant genetics were etched on my brain as something to be considered career-wise," Nelson said.

Basketball came later as a way into Iowa State University, where he studied forestry. "It was during that fifth and final year of forestry school that genetics came back, and, this time, it was forest genetics and something called tree improvement," Nelson said. "It was amazing to me that the same principles that went into making hybrid corn could be applied in various ways to making better trees for forestry; now, that was something I could sink my teeth into."

During his graduate course of study in forest genetics at Oklahoma State University, Nelson was exposed to research on plant disease resistance: first, Melampsora leaf rust on cottonwood; and, second, Eastern Gall rust on jack pine and blister rust on white pine. Later, during his continued exposure to these same rust diseases in a forest genetics Ph.D. program, he realized he was hooked.

"It was during a background study on the fusiform rust disease that I came across numerous articles from the Southern Forest Experiment Station in Gulfport, MS, and a few from Athens, GA," he said. "They were written by people with names like Snow, Powers, Walkinshaw, Kuhlman, Matthews, Kais, and Froehlich. Wow. Now that was really interesting stuff, and to think they were actually paying folks to research this stuff—cool experiments to answer questions posed of nature."

Nelson recalls that it was when he started paying attention to pollinating and growing crosses of black spruce during his Ph.D. days at the University of Minnesota that an elderly gentleman would speak to him and his classmates about chestnuts and backcross breeding them for resistance to chestnut blight. This gentleman was renowned corn geneticist Charles Burnham, and those discussions represented the beginnings of the American Chestnut Foundation's breeding program. "I was indeed fortunate to be around such lofty discussions and even provided an opportunity to make some of the earliest pollinations leading to seeds for the first backcross generation," Nelson said.

A few years later, Nelson was employed as a research geneticist at the Forest Service Southern Institute of Forest Genetics. He now works among the same crowd that he found doing the fusiform rust work at Gulfport, MS, albeit a generation removed, and he is stationed on the Harrison Experimental Forest, a few miles north in Saucier, MS.

"In the early days, we talked about quantitative, or horizontal, resistance and wondered if some of the interactions were due to qualitative, or vertical, resistance that is the result of just a few genes with some special properties," Nelson said. "After extensive research, we discovered the latter to be true, with several qualitative resistance genes genetically mapped, as well as the first corresponding avirulence gene in the rust fungus—a so called 'gene-for-gene' interaction."

Now, years later, Nelson is still intrigued by the work, as he and his colleagues continue their forest genetics research to determine how quantitative and qualitative resistance work together in nature and how best to use this information in tree breeding and forest management. "It should provide fruitful work for some time to come," he said.

During his 16-year career with the Forest Service, Nelson has worked with his colleagues in Mississippi to map genes for resistance to chestnut blight. For the past several years, he has worked with his colleagues to isolate resistant genes from Chinese chestnuts in an effort to transfer them to American chestnuts, using molecular breeding and genetic modification techniques.

"I continue on with fusiform rust and chestnut blight but also have projects underway to test the resistance of longleaf pine to brown spot needle blight and the resistance versus susceptibility among the southern pines to the Nantucket pine tip moth," Nelson said. "Only time will tell how it all works out, but someday I hope we can have American chestnuts back in the eastern forests and be well on the way to fortifying the genomes of all our great forest tree species against the myriad of agents that threaten them."

residential neighborhoods and commercial areas with the least tree canopy cover. This and other Pacific Southwest Research Station research quantifying the benefits and value of California's urban forests was instrumental in the development and approval of Proposition 84. This bond measure is providing $90 million for urban forestry and urban greening projects in California.

Lead: Pacific Southwest Research Station

▲ A view of downtown Los Angeles from the hills. *George Gonzalez, Bureau of Street Services, City of Los Angeles (used with permission)*

Scientists Quantify the Environmental Benefits of Reusing Wood Products

Study evaluated the environmental consequences of reusing two salvaged wood products relative to their virgin wood counterparts

The green building and sustainable construction movement is growing, and building professionals (including architects, material specifiers, contractors, and end users) are increasingly interested in working to reduce environmental impacts from the buildings they create or live in. Reusing recovered building materials from deconstruction or demolition sites is becoming a preferred practice for green building professionals. Therefore, tools for quantifying energy use and greenhouse gas emissions for reusing recovered wood materials are necessary for not only building professionals but environmental policymakers, as well. The objective of this study was to use life cycle analysis to quantify the effect of wood product reuse on greenhouse gas emissions and primary energy usage. Incorporating existing and developed life cycle inventory data, researchers evaluated the environmental consequences of reusing the two salvaged wood products—framing lumber and solid strip wood flooring—relative to their virgin wood counterparts. Virgin life cycle inventory data were already available because of previous work by the Consortium for Research on Renewable Industrial Materials.

▲ Flooring made of old-growth Douglas-fir salvaged from deconstructed military barracks. *Steve Schmieding, Forest Service*

SimaPro modeling generated cumulative cradle-to-gate energy and emission data for the two recovered wood building materials. Findings indicated significantly lower energy and global warming potentials for recovered wood building materials than for their virgin counterparts. Research partners included Athena Sustainable Materials Institute, Ottawa, Ontario, Canada; and U.S. Army Corps of Engineers Engineer Research and Development Center, Construction Engineering Research Laboratory, Champaign, IL.

Lead: Forest Products Laboratory

Natural Landscapes and Recreation Opportunities Attract Future Migrants

Forest Service report offers planning guidance for rural counties

People in the United States move frequently, and they move for many reasons. One reason is a growing desire to live in places with natural landscapes and recreation opportunities. A milder climate and employment opportunity are also important. A Forest Service study, in cooperation with University of Georgia, investigated how natural amenities such as landscape and climate influenced migration patterns in the continental United States over the past two decades. Using recent annual climate, land cover, and natural amenities data, along with recent annual economic and U.S. census migration data at the county level, the researchers created migration models for all rural U.S. counties. The models revealed that migrants prefer varied landscapes that feature a mix of forest land and open space, such as pasture and range land. The models also showed that migrants move for milder winters and cooler summers, and that employment opportunity is a consistently significant driver. Nearby Federal lands are attractive to migrants, reflecting the value people place on the recreation and scenic features of federally designated lands.

Detection of climate change effects on rural migration patterns is another important outcome of this study. Rising sea levels attributed to climate change will affect rural migration. The extent of the effect of climate change on population migration and rural development in rural coastal counties will depend on the degree of vulnerability of property and risk to human health and safety.

Finally, the models show, as a result of changing natural amenities and climate across three future climate scenarios, the Gulf of Mexico, the Atlantic coast, Northern Pacific counties, and the Rocky Mountain Region counties will see the greatest positive change with regard to natural amenities and therefore may experience the greatest influx of migrants.

This research benefits State and county planners, Federal land management agencies, and numerous nongovernmental organizations concerned with rural county population and development, as it offers evidence of the benefits of conserving rural scenic values in rural planning.

Lead: Southern Research Station

Maps of Biomass Dynamics Support North American Carbon Program

Knowing where and at what rates biomass accumulates or is lost across broad scales is critical to understanding how forest disturbance and regrowth influences carbon dynamics

Forest Service scientists and collaborators modeled live, aboveground tree biomass by using Forest Inventory and Analysis (FIA) field data and applied the models to more than 20 years of Landsat satellite imagery to derive trajectories of aboveground forest biomass for study locations across the continental United States. The researchers integrated maps of biomass dynamics with maps depicting the location and timing of forest disturbance and regrowth to assess the biomass consequences of these processes over large areas and long timeframes. These maps enable a first approximation of continental rates of biomass loss and accumulation as a result of forest disturbance and regrowth and can be used to support the North American Carbon Program. Scientists from a variety of universities and Government agencies that model carbon dynamics are using this information. Policymakers and managers now have information to use in understanding how forest biomass has changed over the past 20 years, informing their decisions about how forest management affects biomass change today and in the future. Research partners included Montana State University, NASA Goddard Space Flight Center, Oregon State University, University of Maryland, Northern Research Station, and Rocky Mountain Research Station

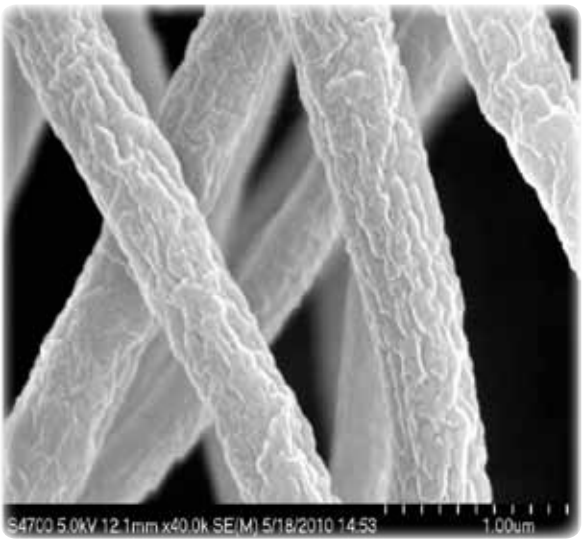
▲ Understanding rates of biomass accumulation is critical to understanding how forest disturbance and regrowth influence carbon dynamics. *Connie Harrington, Forest Service*

Lead: Pacific Northwest Research Station

High-Performance Nano-Cellulose Composites

Researchers study transparent composites for defense applications

Cellulose nanocrystals (CNCs) and cellulose nanofibrils (CNFs) provide strength properties equivalent to Kevlar® and can be used in optically clear applications, such as composite windshields. The Forest Products Laboratory is supporting a project at the Army Research Laboratory (ARL) in Aberdeen, MD, to produce and evaluate primarily clear composites as reinforced glass. The Forest Products Laboratory has been working for 3 years to produce CNCs and the strongest and optically clearest versions of CNFs. In 2009, the ARL approached the Forest Products Laboratory to help with a project producing optically clear composites. Because of the need for larger amounts of materials, the Forest Products Laboratory began a scaleup project to produce both CNCs and CNFs at kilogram scales. The Forest Service provided additional funds for the pilot equipment needed to increase the process scale to about 20 kg. The ARL has been blending CNCs and CNFs in various resins, focusing on poly(methyl methacrylate) (PMMA) as the initial base resin because it provides optically clear panels and films and can be solvent cast. They have succeeded in incorporating CNCs in electrospun PMMA nanofibers at 40 weight percent CNCs. The electrospinning process aligns the CNCs in the fiber and



▲ TEM micrograph of electrospun poly (methyl methacrylate) fibers containing 17 weight percent cellulose nanocrystals. *Alan Rudie, Forest Service*

maintains the dispersion. This enables researchers to laminate sheets with extra PMMA, producing composite sheets. Final sheets contained 1 weight percent CNCs and maintained optical clarity.

Lead: Forest Products Laboratory

Effects of Forest Management on the Functions of Forested Wetlands

Research shows that silvicultural practices in forested wetlands do not necessarily compromise carbon sequestration and productivity

Eleven years after harvesting a wetland forest in the Upper Peninsula of Michigan, Forest Service researchers, in cooperation with Michigan Technological University and Ontario Ministry of Forestry, Canada, went back to measure the change in above- and below-ground carbon and nutrient pools to discern the effects of harvesting. The researchers whole-tree harvested the original stand of black spruce (*Picea mariana*), jack pine (*Pinus banksiana*), and tamarack (*Larix laricina*), and randomly assigned three post-harvest treatments—disk trenching, bedding, and none—to three plots. They also established nine control plots in an adjoining uncut stand. At the time of harvest, the team measured carbon and nutrients in three strata of aboveground vegetation, woody debris, roots, forest floor, and mineral soil to a depth of 1.5 meters. Eleven years after harvest, soil nutrient pools were similar among the three site preparation treatments and the uncut stand. There were differences in ecosystem-level nutrient pools, however, because of differences in live biomass. Coarse roots comprised approximately 30 percent of the tree biomass carbon in the cut stands and 18 percent in the uncut stand. These are the only reported findings on long-term effects of harvesting and site preparation on this particular type of forested wetland, and the results illustrate the importance of understanding the ecohydrology and nutrient dynamics of the wetland forest. This wetland type appears less sensitive to disturbance than upland sites and is capable of sustained productivity under these silvicultural treatments.

Lead: Southern Research Station

▲ Silvicultural practices in forested wetlands such as this do not necessarily compromise carbon sequestration. *Forest Service*

Assessing the Vulnerability of Northern Wisconsin's Forests to Climate Change

Assessment summarizes multiple scientific research efforts and synthesizes the issues most salient to land managers

A recent publication—*The Ecosystem Vulnerability Assessment and Synthesis*—assessed and summarized the potential effects of climate change on the forests of northern Wisconsin. Scientists from the Northern Research Station and University of Wisconsin modeled climate change effects on forest productivity and the suitability of habitat for specific tree species as well as the potential changes in forests that are most important for land management. This assessment is part of the larger Northwoods Climate Change Response Framework project in Minnesota, Michigan, and Wisconsin, which is developing an integrated set of tools, partnerships,

and actions to support "climate-smart" conservation and management. Other research partners include Michigan Technological University, Wisconsin Department of Natural Resources, and Wisconsin Initiative on Climate Change Impacts.

Lead: Northern Research Station

Labels Help Consumers Evaluate the Environmental Impacts of Wood Products

Environmental product declarations summarize the environmental impacts associated with a product or service in a way that is meaningful to consumers, much like nutrition labels

Transparent and credible environmental labeling of products is vital for a sustainable future. To aid in developing a sustainable future, evaluating products for their environmental impact using life cycle assessment (LCA) has become a growing research area. LCA, a science-based methodology, examines products from the point of extracting raw materials for manufacturing the products to the point of final disposition. The results, however, can be hard for the general public to interpret. Environmental product declarations (EPDs) provide a transparent and credible way of demonstrating to consumers and business the environmental benefits of choosing one product or another, much like using nutritional labels. This project was initiated, in cooperation with University of Tennessee and the Athena Sustainable Materials Institute, to disseminate information on the potential use of LCA-based EPDs in the forest products industry.

▲ Environmental Product Declarations (EPDs) for Wood sample. *Forest Products Society (used with permission)*

Lead: Forest Products Laboratory

Science Solution

New Software Tool Used in Japan To Protect Drinking Water After Earthquake

Tool assessed movement in rivers of radioactive contaminants from damaged reactor

▲ Douglas Ryan, Forest Service Scientist. *Forest Service*

A team of scientists led by Forest Service scientist Douglas Ryan developed a software tool that a U.S. Department of Defense agency used to assess the movement in Japanese rivers of radioactive contaminants released from Japan's earthquake-damaged Fukushima Daiichi nuclear power plant. The Incident Command Tool for Protecting Drinking Water, or "ICWater," enables incident commanders and water utility managers to rapidly assess risk to drinking water during toxic spill emergencies. Results of the analysis, performed for the Defense Threat Reduction Agency by the SAIC Corporation, were shared with emergency managers in Japan for use in assessing risk of waterborne radioactivity to the Japanese public in the aftermath of the accident.

ICWater is a software tool that was developed to predict impacts of contaminant releases, including radioactive materials, to surface waters. ICWater integrates multiple information sources at the scene of an emergency and quickly produces maps, tables, and charts that identify whether drinking water intakes are in the contaminant's path, and when and in what concentration the contaminant will reach the intakes. It also analyzes the effects from deposition of toxic materials from airborne plumes and tidal influence on river flows in coastal areas. The tool provides decisionmakers with a rapid assessment of risk for use in deciding what actions will best protect the public in emergencies involving toxic spills.

Ryan led the ICWater development team that included "Team eH2O," led by Bill Samuels at SAIC's Center for Water Science and Engineering. The Defense Threat Reduction Agency currently distributes the ICWater tool to U.S. Government agencies under a memorandum of understanding with the Forest Service.

Resource Management and Use

Street-Level Views of Climate Change

Findings will help the city of Chicago shape its Climate Action Plan outreach to residents

Forest Service scientists, in partnership with the Field Museum and Chicago Department of Environment, investigated climate-friendly attitudes and behaviors in two Chicago neighborhoods to help the city implement its Climate Action Plan. Some residents were aware of climate change and the actions they could take to minimize its effects. Many others were less aware of climate change but nonetheless engaged in some climate-friendly practices that the plan could support and build on. The research suggests that, to advance the goals of the Climate Action Plan at the neighborhood level, Chicago needs to understand the issues of importance in each neighborhood, assess the ways these issues are related to climate change mitigation or adaptation, and develop climate change goals that address residents' concerns.

Lead: Northern Research Station

▲ What three words come to mind when you hear "climate change?" This "word cloud" captures the responses of North Kenwood–Oakland residents. *Field Museum (used with permission)*

Researchers Monitor Moisture-Control Treatments in Crawl Spaces in Louisiana

Six different insulation systems are evaluated on their ability to prevent moisture buildup in floors

In flood-prone areas, elevating the floor system of a building above the anticipated flood level can significantly limit the extent of property damage associated with flooding. In hot and humid climates, such as the Gulf Coast region, homes have long been constructed with raised floors on crawl space foundations. Recent changes to building energy codes require floors to be insulated. Most residential buildings in the Gulf region are now air-conditioned. The combination of floor insulation and air-conditioning, however, may put floor systems at risk for summertime moisture accumulation and related problems, such as mold growth, decay, corrosion, and expansion/contraction damage. In response to a research gap and a regional need, researchers from the Forest Products Laboratory, in cooperation with Louisiana State University Agricultural Center, monitored moisture and temperature levels in a dozen homes in New Orleans and Baton Rouge, LA. This research confirmed several trends that were expected, relating to the effects of summer air-conditioning temperatures and impermeable interior floor finishes. The research found that foil-faced rigid foam board and closed-cell sprayed polyurethane foam insulation performed well, keeping subfloors from accumulating moisture. This work provides a research basis for builders, contractors, homeowners, architects, and building officials to make informed decisions.

▲ Homes with raised floors in New Orleans, LA. *Samuel V. Glass, Forest Service*

Lead: Forest Products Laboratory

Study Forecasts South May Lose 23 Million Acres of Forests Over the Next 50 Years

Southern Forest Futures Project will inform policy and management choices

The Southern Forest Futures Project provides forecasts of forest conditions and describes implications of alternative

futures for a series of ecosystem services and resource conditions, labeled meta-issues. The project intends to inform policy and management choices with a thorough discussion of potential resource scarcities and a range of plausible future forest conditions in the U.S. South. The Futures Project forecasts the effects of urbanization, bioenergy use, climate change, land ownership changes, and invasive species over the next half-century and discusses how those influences may affect water, wildlife, fire, and other issues. These concerns emerged through a series of public meetings held throughout the 13 Southern States.

The Southern Research Station economics unit's project leader, David Wear, served as co-leader of the project, and the unit provided 8 of the 17 chapters of the technical report, with four unit scientists participating. The unit's forest forecasting team, a cooperative effort with North Carolina State University, provided all technical forecasts at the foundation of the Futures Project. More than 30 scientists, researchers, foresters, and other experts with the Forest Service, State forestry agencies, and universities contributed to the study.

Lead: Southern Research Station

▲ The Southern Forest Futures Project forecasts conditions and influences decisions. *Forest Service*

Wood Chips Pretreated With Oxalic Acid Return Positive and Negative Results

Researchers studied how pretreating wood chips before manufacturing medium-density fiberboard affected both the end product and the amount of carbohydrates extracted as a potential resource for biofuels or biobased chemical production

The concept of value prior to pulping (extracting components from wood before it is pulped for production of chemical and liquid fuel products) has been proposed in the pulp and paper sciences because of renewed interest in cellulosic biofuel production. In cooperation with BioPulping International, Inc., and Central South University of Forestry and Technology, China, Forest Products Laboratory researchers evaluated the effect of oxalic acid (OA) pretreatment of wood chips before refining on both energy reduction during the refining process and the physical performance of medium-density fiberboard (MDF) manufactured using this pretreated fiber. In addition, the Forest Products Laboratory investigated the effect of the OA treatment on carbohydrates from wood. The results showed that the OA treatment significantly reduced refining energy and improved MDF panel dimensional stability and lightness. The OA treatment, however, had a negative effect on the internal bonding strength of MDF panels. The amount of extracted carbohydrates dramatically increased, up to 24 times, by the use of OA in the pretreatment. Carbohydrates extracted from wood chips could be a potential sustainable resource for biofuel or biobased chemicals.

Lead: Forest Products Laboratory

▲ Aqueous extract solutions under different pretreatments. *Steve Schmieding, Forest Service*

Project SMART

Conservation education program educates and motivates talented high school students in math and science

Forest Service funding from the Northern Research Station's Civil Rights Diversity Committee's Special Project Funds and Conservation Education's More Kids in the Woods helped 39 students from several States and foreign countries attend Project SMART (Science and Mathematics Achievement Through Research Training), a 4-week summer institute at the University of New Hampshire. Students participating in Project SMART put science into action through research

▲ Project SMART provides opportunities for students to conduct hands-on research in environmental sciences. *Stephanie Meyer, Forest Service*

projects in areas of marine and environmental science, biotechnology and nanotechnology, and space science. The students attended the Project SMART Summer Institute on the university campus in July 2011. The Forest Service collaborated with the university and Liberty Mutual Foundation to offer this exceptional experience to a diverse audience, including students from 11 States and 3 countries—Greece, Turkey, and India. They researched various topics, including monitoring terrestrial and aquatic systems in the White Mountains and other forest management practices, climate change and its effect on forest productivity, and forest health. Several students are expected to continue these research projects during the academic year and will present their findings at regional high school science symposia to compete for tuition and cash scholarships. It is not just about learning, however; the program has given these lucky students long-lived memories and friendships with students and university staff.

Lead: Northern Research Station

Residue From Forest Thinning Finds a Purpose in Commercial Products

Researchers found aspen slash wood could be a valuable resource for commercially available structural panel products

The disposal of forest thinning residue is a concern when looking at sustainable forest management. Forest Products Laboratory researchers, in cooperation with the International Center for Bamboo and Rattan, China, investigated the technical possibility of using aspen logging slash wood with diameters ranging from 50 to 76 mm for flakeboard production. Researchers examined the influences of the weight ratio between slash wood and commercial flakes on the selected mechanical and physical properties of panels and the need for extra debarking processes for panel fabrication. The results indicated the modulus of elasticity, modulus of rupture, internal bonding, linear expansion, thickness swelling, and water adsorption of flakeboard made from aspen slash wood flakes were all comparable to those properties of panels made from aspen commercial flakes. The results indicated abundant slash wood, which was normally characterized by inferior mechanical and physical properties, could be a valuable resource for commercially available structural panel products.

Lead: Forest Products Laboratory

▲ Typical aspen slash wood (left) and flakes (right) sliced from the slash wood. *Steve Schmieding, Forest Service*

The Future of Mahogany

New computer model encourages sustainable harvest of this valuable species

The very name "mahogany" is synonymous with luxury and sophistication. This beautiful wood has been traded internationally since the Spanish discovered its natural forests around 1500, when they colonized Mexico and Central America. Mahogany is more than a pretty plank—its strength, light weight, resistance to rot, and structural stability made it an ideal timber for oceangoing vessels as well as the large bureaus and other furniture perched on delicate legs and feet that 19th century Britain loved. Mahogany also occupies an important position in the ecosystem, insofar as it is a large tree that emerges above the forest canopy and many other species depend on it for habitat and survival. Sadly, mahogany's great value has also been its undoing over

the past half century or so, as modern industrial logging techniques made it commercially viable to extract mahogany from primary forests hundreds of miles from the nearest village or town in the Amazon River basin.

"The future of mahogany as we know it depends on whether sustainable harvest systems can be designed for natural forests where mahogany still survives, especially in South America," said field ecologist Jimmy Grogan, whose mahogany research has been funded by the Forest Service through the International Institute of Tropical Forestry since 1995. "Plantation-grown mahogany may replace current natural-grown supplies to some extent, but the wood is of lower quality because it grows extremely fast without competition from other species."

To help forest managers sustain timber production of mahogany from natural forests so the species may continue to benefit current and future generations, Grogan and his colleagues developed the Big-Leaf Mahogany Growth & Yield

Profile in Science—Jimmy Grogan

What is it like to do research in the Brazilian rain forest?

For most of my adult life I have lived and worked abroad, including spending many years in Indonesia, Thailand, and Malaysia, so it was not too difficult adjusting to life in the Brazilian Amazon. I learned to speak Portuguese in the field; my tutors were the field assistants whom I hired locally. Considering that mahogany is "the panda bear of tropical timber," as I like to call it, the politics of doing research on this species are incredibly convoluted and complicated. That side of my research has been almost as educational and fascinating as the actual fieldwork.

Politics aside, I have been fortunate to live and work in remote forests, with no villages or towns nearby, no noise or light pollution, no electricity, and no running water when the streams dry up during the dry season. Under those conditions, it is possible to experience forest life on a very satisfying level. As a plant ecologist, I can observe the daily and seasonal rhythms of growth and dormancy at the level of the forest community—that is, the growth, flowering, and fruiting schedules that trees and other plants keep through the year and from year to year. Being there every day in the middle of it, I saw these rhythms gradually come into focus, and I see the forest come alive in a way that feels completely integrated.

Many people find it surprising to learn that the Brazilian rain forest and the other tropical forests I have worked in are not perpetually wet and steaming. Mahogany grows naturally only in tropical forests that have a pronounced dry season for one-third to one-half of the year. So we can go for months at our research sites without rain. When that happens, the streams dry up, the trees drop their leaves, the understory goes brown, the ticks and deerflies come out, and everything gets wilted in the heat until the rains come back.

▲ Forest Service field ecologist Jimmy Grogan at the Marajoara field site in southeast Pará, Brazil. The sororoca plant with the wide leaves is a relative of the banana. Although this photo was taken in daytime, the light level is low because the researchers are in the forest understory. *M. Loveless, Forest Service*

The most important thing people should know about mahogany is the same thing they should know about other living species that we humans consume—if consumption exceeds supply indefinitely, supply will vanish. It is probably unlikely that people can push mahogany to biological extinction, because nowadays it is grown in plantations all over the world, but the human race is definitely capable of eliminating commercial supplies from natural forests.

For more information about our work in the Brazilian rain forests, visit our Web site, http://www.swietking.org/. Although the site is undergoing a major reconstruction right now, by the end of 2011 the growth and yield model will represent a small subsection of a Web site dedicated to all things mahogany.

▲ Field assistants measure mahogany tree diameter near the agricultural town of Agua Azul in southeast Pará, Brazil. *J. Grogan, Forest Service*

Model, which simulates logging and then "grows" populations between harvests according to demographic algorithms constructed from 15 years of annual census data in Brazil. The model simulates actual mahogany populations in Brazil and allows anyone with actual or fictional mahogany populations to upload their data for simulations. After the population data is in the model, it is programmed with several rules or parameters, such as the number of years between harvests, the minimum legal cutting diameter (currently 60 cm in Brazil), the percentage of commercial-sized trees that must be retained after logging for regeneration purposes, and the minimum density of commercial trees below which logging is not allowed.

After all the parameters are set, the model harvests the population, grows it until the next harvest, and repeats the cycle. At the end of a simulation, the model tabulates the results (e.g., the total number of trees, the commercial volume harvested, and the number of live trees at the end of a simulation) and gathers the outcomes into an Excel® spreadsheet. Forest managers in Brazil, Peru, and Bolivia are the intended users of the model. Forest regulators could also use it to verify whether production data from a given management area are realistic and sustainable.

"Forest Service support for mahogany research makes a lot of sense because the United States has been the principal importer of internationally traded mahogany since World War II," said Grogan. "It is in our best interest, and the best interest of future generations of consumers who deserve the same opportunity to use and enjoy mahogany as we do, to invest in research aimed at improving its harvest and management practices."

Grogan's work also receives generous support from Brazilian timber companies that own the sites where Grogan and his colleagues, Mark Schulze, Marco Lentini, and Edson Vidal, conduct their research. Grogan also works with a core group of research assistants, hired locally, who have been associated with the project since 1995. In Brazil, Grogan is affiliated with the Instituto Floresta Tropical in Belém. He built the Big-Leaf Mahogany Growth & Yield Model from demographic data published in scientific journals over the past decade. The model and articles on which it is based are available on line, free of charge, at http://www.swietking.org/.

Lead: International Institute of Tropical Forestry

Study Examines the Effect of Various Pretreatments on the Performance of Rice Straw Particleboard

Carbohydrates extracted from rice straw particles could be a potential sustainable resource for biofuel or biobased chemicals

Particleboards are widely used for construction, furniture, and interior decoration. Wood is the primary material used in the particleboard panel industry, but because of competition for wood raw materials and economical and environmental considerations, interest has recently revived in using agriculture residues to produce particleboards and other composite panels. Globally, wheat and rice are the most important food grains, ranking second and third, respectively, in terms of the total cereal production, and appear to be the most promising agriculture residues for manufacturing composite panels. The objective of this study was to evaluate the effect of OA and steam pretreatment on the primary performance of rice straw particleboards. In addition, the study investigated the effect of various treatment conditions on carbohydrates released from rice straw particles. The results show that steam and short durations of OA treatment significantly improved the mechanical properties and dimensional stability of rice straw particleboards. Steam-treated rice straw (without OA treatment) panels, however, exhibited even better performance when compared with OA-treated panels. OA pretreatment time has a negative effect on performance of panels, whereas the effect of temperature on the performance of OA-treated panels was not significant, except for the linear expansion. OA treatment accelerated carbohydrate extraction. The sugars released from the OA-treated rice straw particles increase with increasing treatment temperature and time. Carbohydrates extracted from rice straw particles could be a potential sustainable resource for biofuel

▲ Rice straw appears to be a promising agricultural residue for manufacturing composite panels. *William M. Brown Jr., courtesy of Bugwood (www.bugwood.org)*

or biobased chemicals. This study was in cooperation with Central South University of Forestry and Technology, China.

Lead: Forest Products Laboratory

Strategically Linking Headwater Habitats Across Ridgelines Benefits Amphibians and Management

A new design maintains amphibian habitat while anticipating land managers' future needs in response to climate change

Forest disturbances can interrupt the movement of stream-breeding amphibians over land across forested ridgelines to adjacent drainages. To mitigate these interruptions, Pacific Northwest Research Station scientists, in cooperation with Bureau of Land Management and Earth Systems Institute, developed criteria for placing and managing dispersal corridors, extending out from headwater riparian reserves, up and over ridgelines, to the neighboring headwater riparian area. This design considers placing linkage areas at stand-to-landscape scales; for example, (1) in north–south directions, to allow population resiliency in the face of climate change; (2) across watershed boundaries that have no aquatic connectivity; (3) at landscape nodes where three discrete watersheds join; and (4) by colocating linkages with debris flow-prone areas, existing reserves, and Federal lands. Scientists modeled this approach for the Oregon Coast Range. Federal biologists, land managers, and watershed stewardship councils are considering implementation of this design on several national forests in the Pacific Northwest Region and on Federal lands in Arizona and New Mexico.

Lead: Pacific Northwest Research Station

Hubbard Brook Environmental Literacy Program

A partnership promotes understanding and stewardship of ecosystems through scientific research, long-term monitoring, and education

At the Forest Service's Hubbard Brook Experimental Forest in New Hampshire, the agency is a partner with the nongovernmental Hubbard Brook Research Foundation in statewide efforts to strengthen teachers' abilities to analyze and interpret real ecological data with their students. With partners from

▲ The coastal tailed frog is one of many species that likely would benefit from linked headwaters that facilitate connectivity among gene pools of subpopulations in adjacent watersheds. *Loretta Ellenburg, Forest Service*

▲ Educators can now use Hubbard Brook Experimental Forest's long-term data sets to teach inquiry in their classrooms. *J. Wilson, Hubbard Brook Research Foundation (used with permission)*

across the State, the Foundation's Environmental Literacy Program is creating innovative science inquiry programs for middle and high school educators using data sets and real life examples from the Hubbard Brook Experimental Forest. Partnerships with local schools help the program and its partners brainstorm, develop, and test new materials, such as New England Common Assessment Practice exams to help students understand the process of science, not just the results. Partners in this program include the New Hampshire Education and Environment Team, Long-Term Ecological Research Network's Schoolyard Program, New Hampshire Project Learning Tree, New Hampshire Fish and Game, The GLOBE Program, New Hampshire Project WET, New Hampshire Project WILD, The HOMES Program, and New Hampshire Department of Education.

Lead: Northern Research Station

More Scotch Broom Found Where Logging Debris Was Removed

Scotch broom, a nonnative invasive species, is a severe competitor of young Douglas-fir

A scientist with the Pacific Northwest Research Station, with research partners from Green Diamond Resource Company and the Virginia Polytechnic Institute and State University, conducted a study to see if the presence or absence of logging debris affected planted Douglas-fir and associated vegetation. Their study sites included areas where loggers removed only harvested logs, leaving behind branches and treetops, and areas where loggers took all branches and treetops off site. The researchers found that intensive forest harvesting practices that remove most of the logging debris will increase abundance of Scotch broom. Three years after debris was removed, Scotch broom, which was present in the understory before forest harvesting, covered 26 percent of the area, whereas it covered 6 percent of the area where debris was retained. In the fourth year after the debris treatments, survival of planted Douglas-fir was lower where debris was removed (62 percent) compared with where it was retained (79 percent). This information will help land managers increase productivity of forest plantations by reducing the negative, indirect effects of debris removal.

▲ Woody debris after logging was removed at this site, and 3 years later Scotch broom, a nonnative invasive shrub, covered 26 percent of the area; it covered only 6 percent of the area when logging debris was left on site. *Tim Harrington, Forest Service*

Lead: Pacific Northwest Research Station

Soy-Based Adhesives for Wood Products Meet Emission Standards

Commercialized products enable wood manufacturers to replace adhesives based on fossil fuels with biomass-based adhesives

The California Air Resources Board has implemented new standards that set lower acceptable formaldehyde emission levels for products sold in California than those established by the current voluntary standards in the United States. Soy-based adhesives are used to make interior (decorative) plywood, particleboard, and medium-density fiberboard that meet all the current and future established standards for formaldehyde emissions. Ashland–Hercules, working cooperatively with the Forest Products Laboratory, developed these soy-based adhesives and has commercialized them for interior plywood, engineered wood flooring, and particleboard. This technology also enables wood manufacturers to replace adhesives based on fossil fuel with biomass-based adhesives. More than half the interior plywood market is currently using soy-based adhesives.

Lead: Forest Products Laboratory

▲ Bonded wood panel products made with soy adhesives. *Steve Schmieding, Forest Service*

Environmental and Economic Benefits of Short-Rotation Poplar Energy Crops

Woody production systems and conversion technologies help maintain healthy forests and ecosystems, create high-paying manufacturing jobs, and meet local energy demands

Poplar energy crops have been extensively studied throughout North America for a half-century and are one of many alternative feedstocks contributing to energy security. Building on work that began in the late 1960s, Forest Service scientists and their partners have completed extensive studies that tested the genetics, physiology, and silviculture of poplar crops in a regional network of field trials first established in 1995. They are currently studying the carbon implications of 10- and 20-year-old plantations throughout the Midwest.

▲ Eight-year-old poplars ready for harvesting. *R. Zalesny, Forest Service*

▲ Industrial energy crop plantation. *R. Zalesny, Forest Service*

They have analyzed biomass, rooting, and other important traits from hundreds of genotypes grown throughout the Northern United States, as well as tree growth-regulating mechanisms in the face of varying environments and changing climate. These results are currently being used to increase the energy potential of the trees and increase the efficiency of plantation establishment, which helps meet U.S. energy demands. Research partners include Iowa State University, Michigan State University, University of Idaho, GreenWood Resources, Inc., Verso Paper, University of Minnesota–NRRI, University of Minnesota, University of Georgia, University of Wisconsin, Canadian Agroforestry Development Centre, and Gustav Luedemann GmbH.

Lead: Northern Research Station

▲ Poplar trees harvested after 10 years in Ames, IA, for biomass and carbon sequestration analysis. *R. Zalesny, Forest Service*

Presence of Tanoak Reduces Douglas-fir Mortality From Black Stain Root Disease

Black stain root disease is a native pathogen of conifers in the Pacific Northwest that reduces growth and ultimately kills the infected tree

As part of a study on the effects of tanoak competition on Douglas-fir, a scientist with the Pacific Northwest Research Station discovered that where tanoaks and other hardwood had been retained in the stand, less mortality from black stain root disease occurred in 20- to 24-year-old Douglas-fir compared with stands where all tanoaks had been removed when the stand was 2 years old. The Forest Service scientist hypothesized that the presence of hardwood roots slowed conifer root growth and served as a physical barrier to the

spread of disease. On public lands in southwestern Oregon, where this study took place, forest managers are already retaining low to moderate densities of hardwoods to increase biodiversity and provide wildlife habitat; such practices should also reduce the spread of black stain. Research partners include Oregon State University and the Rogue–Siskiyou National Forest.

Lead: Pacific Northwest Research Station

Forest Products Laboratory Transfers Technology for Panel Products

Two startup companies commercialize building panels made from forest residues

Fundamental and applied research is being successfully transferred to two industrial partners. The two startup companies are developing panel products that use technology developed at the Forest Products Laboratory. This year, significant consultations have helped move these two companies closer to commercial reality. One company, BioSIPs Inc., is developing a line of furniture and structurally insulated panels. The other company, ECOR® Global, is focusing on furniture, office partitions, and architectural materials panels. The companies can make panels from forest residuals, recycled fiber, and agricultural fibrous byproducts. All raw panels made at the Forest Products Laboratory were naturally bonded and formaldehyde free. The Forest Products Laboratory is continuing to help these companies with technology transfer issues so that they can be in production in the near future.

Lead: Forest Products Laboratory

▲ Panels made from recycled fiber and based on Forest Products Laboratory research are being commercialized. *Steve Schmieding, Forest Service*

U.N. Panel Finds Synergistic Approaches for Global Forest Governance

A panel of experts from around the world convened in Vienna to assess why global forest governance seems to be failing in spite of efforts by many countries

Forest Service researchers worked with colleagues from around the world in 2010 as part of the International Union of Forest Research Organizations' Global Forest Expert Panel on the International Forest Regime to assess the complex elements that make up global forest governance and to provide policy- and decisionmakers with recommendations (http://www.iufro.org/science/gfep/forest-regime-panel/). Their advice centers on the notion that the complexity of forest problems rules out simple governance solutions; therefore, the most pressing challenge for global forest governance is not how to simplify the existing, complex international regime, but how to improve institutional collaboration and coordination in ways that build more effective and enduring forest governance. The recommendations offer solutions for adding both vertical and horizontal forest structure and function to collaborative and coordinating efforts on forest governance. This goal can be realized by integrating problem-focused and on-the-ground learning about governance mechanisms and arrangements. The panel's recommendations largely build on the existing strengths of the international forest governing bodies and require few new "parts," but call for more focused learning and better use of existing forest governance successes. Results of the panel's work were presented to the 10th Conference of the Parties to the Convention on Biological Diversity in October 2010 and

▲ Shifting agriculture and forest fragmentation in Nicaragua exemplify some of the complex challenges addressed by the international forest governance regime. *Kathleen McGinley, Forest Service*

the ninth session of the United Nations Forum on Forests in January 2011.

Lead: International Institute of Tropical Forestry

Oregon White Oak Regeneration Enhanced Through Proper Seed and Seedling Management

A new report is the first comprehensive study of Oregon white oak planting technique

Oregon white oak (*Quercus garryana*) has become a species of conservation emphasis for several State and Federal agencies and nongovernmental organizations in Oregon and Washington. The tree is now found in a fraction of the area in which it was found before Euro-American settlement. Cost-sharing programs are available for reestablishing the oak on the landscape, but before recent work by station scientists, planting recommendations were based on guidelines for other oak species in different regions of North America and Europe, or on guesswork. Scientists with the Pacific Northwest Research Station, in cooperation with Southern Oregon University, Washington Department of Natural Resources, and Webster Nursery, have conducted several studies specific to Oregon white oak. They found that proper acorn storage, nursery practices, and container culture can improve root morphology and lead to improved success of seedlings in the field. Many people planning regeneration programs have quickly adopted this information. The Forest Service has widely distributed a summary publication on regenerating native oak in the Pacific Northwest and received requests for nearly 2,000 copies during the first 4 months after publication.

▲ Science-based guidelines for planting and caring for Oregon white oaks have been quickly adopted by people planning regeneration programs to halt the decline of this native tree. Here a technician examines growth on an oak seedling 8 years after planting. *Warren Devine, Forest Service*

Lead: Pacific Northwest Research Station

Science Solution

New i-Tree Software Puts a Value on Urban Trees

Trees can provide millions in benefits

In 2011, the Forest Service and its partners released a new version of their free software, i-Tree v.4, which provides urban planners, forest managers, environmental advocates, and students a tool to measure the ecological and economic value of the trees in their neighborhoods and cities.

The Forest Service partnered on the project with The Davey Tree Expert Company, the National Arbor Day Foundation, the Society of Municipal Arborists, the International Society of Arboriculture, and Casey Trees. The Forest Service and its partners also offer free and easily accessible technical support for the i-Tree software suite.

"Urban trees are the hardest working trees in America," said Forest Service Chief Tom Tidwell. "Urban trees' roots are paved over, and they are assaulted by pollution and exhaust, but they keep working for us." Urban trees provide temperature control, clean water, and clean air and mitigate climate change by sequestering tons of carbon.

The i-Tree suite of tools has helped communities of all sizes gain funding for urban forest management and programs by quantifying the value of their trees and the environmental services trees provide.

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Water, Air, and Soil

The **Water, Air, and Soil** SPA informs the sustainable management of these essential resources through information on how to provide clean air and drinking water, protect lives and property from wildfire and smoke, and improve the ability to adapt to climate variability and change. It encompasses studies on ecosystem services with integration between water, air, and soil research. The SPA notes the effects of climate variability and change on water budgets.

A New Way To Conduct Urban Research

Coalition of scientists comes together to model San Juan

Traditional urban research involves tree inventories, census activities, water quality sampling, or socioeconomic studies, all conducted by separate scientists on separate locations and with separate questions. Forest Service researchers at the agency's International Institute of Tropical Forestry in San Juan, PR, asked themselves whether it might be better to create a new coalition of scientists with all kinds of specialties, who, together, could study a city.

In answer to their question, more than 60 scientists, students, and collaborators designed a network of research sites and data-gathering procedures to study the city socioecologically. The participating scientists all worked in San Juan, but most had never met each other or worked together before the project began. Before embarking on the project, they first had to learn each other's technical languages because the same word often has different meanings in the social and natural sciences; then, they jointly developed a model of the city. The resulting socioecological sampling grid for the Rio Piedras River watershed and San Juan emerged after conducting workshops, field trips, community consultations, and literature reviews.

The group took a watershed approach to satisfy quantitative and modeling approaches dealing with energy and mass balances of city functioning. The researchers stratified the city by natural (e.g., geology, topography) and socioeconomic (e.g., income level, land cover, population density) criteria. The researchers randomly selected circles, 1 kilometer in diameter, to ensure complete coverage of the watershed and experimental replication. Inside these circles, natural scientists could sample biodiversity and social scientists could study people, households, and neighborhoods, as long as they worked together. Field crews included representatives with social and natural science backgrounds, and the crews developed and administered questionnaires for interviewing people.

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One recent i-Tree study found that street trees in Minneapolis, MN, provided $25 million in benefits, ranging from energy savings to increased property values. Urban planners in Chattanooga, TN, were able to show that for every dollar invested in their urban forests, the city received $12.18 in benefits. New York City used i-Tree to justify $220 million for planting trees during the next decade.

Since the initial release of the i-Tree tools in August 2006, more than 100 communities, nonprofit organizations, consultants, and schools have used i-Tree to report on individual trees, parcels, neighborhoods, cities, and even entire States.

The most important improvements in i-Tree v.4 are the following:

- i-Tree will reach a broader audience in educating people on the value of trees. i-Tree is designed for easy use by homeowners, garden centers, and school classrooms. People can use i-Tree Design and its link to Google maps to see the effect of the trees in their yard, neighborhood, and school yard, and what benefits they can see by adding new trees. i-Tree Canopy and VUE, with their links to Google maps, now also make it much easier and less expensive for communities and managers to analyze the extent and value of their tree canopies, analyses that up to this point have been prohibitively expensive for many communities.
- i-Tree will also expand its audience to other resource management professionals. i-Tree Hydro provides a more sophisticated tool for professionals involved in stormwater and water quality and quantity management. Hydro is a tool that can be applied immediately to help communities evaluate and address the effects of their urban forests on stream flow and water quality, which could be helpful in meeting State and National clean water and stormwater regulations and standards.

With each new release of i-Tree, the tools become easier to use and more relevant to the users. The i-Tree developers are continually addressing feedback from users and adjusting and improving the tools so that they are easier for a much broader audience to use.

▲ Socioecological sampling grid for the Rio Piedras River Watershed and San Juan. The orange boundary delineates the Municipality of San Juan; the blue boundaries delineate the watershed and subwatersheds of the Rio Piedras. Socioecological sampling occurs within the circles. *Ariel Lugo, Forest Service*

The city model the scientists developed is a heuristic, or experience-based, model that depicts both the natural and anthropogenic forces, components, and fluxes of the city. It will evolve into a variety of computer models that display future scenarios of city sustainability. Normally, a natural scientist does not include history in a model of energy flux, and a social scientist will not include energy limitations in models of city function; but together they can uncover social and natural constraints that keep a city from functioning as well as it can.

The study's objective is to empower communities as they work with city managers and to provide critical information to city managers about all aspects of the city for which they have responsibility. The communities do not create a city plan, but they provide knowledge and insight to improve the city planning process. Knowledge about cities is often fragmented and usually ignores their environmental aspects. This study is working to close those knowledge gaps. International Institute of Tropical Forestry Director Ariel Lugo said his first attempt to marry social and natural sciences was in 1972, and he concluded it was impossible to achieve. "With this socioecological approach, I have seen the light again, and that is why I think just establishing ULTRA [the Urban Long Term Research Area] is a highlight," Lugo said. "We are unleashing a new powerful force that will transform the way we do science and view the human–nature dichotomy." Research partners include University of Puerto Rico; Arizona State University; Clark University; State University of New York at Syracuse; University of New Hampshire; University of California, Los Angeles.

Lead: International Institute of Tropical Forestry

▲ Social and ecological scientists collecting data in the city. *Ariel Lugo, Forest Service*

The Role of Salmon-Derived Nutrients in Southeast Alaska Watersheds

Soil type plays a critical role in the nutrient cycle that connects salmon to terrestrial ecosystems in coastal temperate rain forests

After salmon return from the ocean and spawn upstream, they die, and their spent carcasses wash up along the streambanks. As the carcasses decompose, their nutrients are cycled back into the terrestrial system. Forest Service scientists and collaborators from University of Notre Dame tested a long-held assumption that the nutrients of decomposing salmon cycle back into the terrestrial system by delineating riparian zones along salmon spawning channels on Prince of Wales Island in southeast Alaska. They found two distinct soil types in those zones and tested the soils' responses to the presence of decaying salmon by measuring the amount of the nitrogen isotope ^{15}N present. Historically, scientists have used the ^{15}N isotope, which is abundant in the ocean but not as common in terrestrial systems, to trace presumed salmon-derived nutrients in riparian systems. Contrary to conventional wisdom, the scientists found that soil closest to the stream (which happened to be the younger soil) had significantly lower concentrations of the nitrogen isotope ^{15}N compared with the older soil found farther away from the stream. From this research, the scientists developed a model

that constrains the natural variability encountered in studies of riparian nutrient cycles associated with the feedbacks between salmon-derived nutrients and terrestrial ecosystems. This model will help improve estimates of the fate of salmon-derived nutrients in soils and vegetation.

Lead: Pacific Northwest Research Station

▲ Field crew collecting soil samples on the banks of Rio Roberts creek on Prince of Wales Island, Alaska. *Dave D'Amore, Forest Service*

New Protocols Help Land Managers Understand Changing Soils

Forest Service scientists develop meaningful soil quality standards to evaluate the full range of variability found in forest soils

Productive forest soils are the underpinning for sustainable forest activities, and monitoring is the key to ensuring that land management has not altered productivity. The Multiple Use Sustained Yield Act of 1969 and the National Forest Management Act of 1976 govern, in part, maintenance of soil quality on NFS land. The challenge has been to develop meaningful soil-quality standards that can evaluate the full range of variability found in forest soils. Many forest soils are resilient, while others are at risk after land management treatments. Rocky Mountain Research Station scientists developed a standardized forest soil monitoring protocol that uses visual classifications to describe the degree and extent of soil disturbance and that helps managers determine if those effects are detrimental to long-term site productivity. The Forest Service issued a letter in 2010 endorsing this soil monitoring protocol as a statistically rigorous, standardized, rapid assessment of pre- and post-harvest soil disturbance that provides repeatable and consistent methods to describe changes in soil physical conditions. The Rocky Mountain Research Station has published two field guides that describe the field methods and statistics of soil monitoring, as well as a picture guide to the disturbance categories, and developed an online training curriculum. In addition, the station sponsored workshops in every Forest Service region to outline the protocol and conduct field training sessions. All publications and training materials are available under the "Forest Soil Disturbance Monitoring Toolkit" section at http://forest.moscowfsl.wsu.edu/smp/solo/InfoPath/monitoring/documents.php#reference.

▲ Training sessions such as this one in the Pacific Southwest region ensure that the Forest Soil Disturbance Monitoring Protocol is used consistently across national forests in the United States. *Deborah S. Page-Dumroese, Forest Service*

Lead: Rocky Mountain Research Station

Chloride Concentrations in Recovered Hydraulic Fracturing Fluid Increase With Depth of Tank

The hydraulic fracturing fluid used in natural gas extraction in the northeastern Appalachians raises concerns about safe disposal

Natural gas production has increased in recent years in the northeastern Appalachian forests. The natural gas generally is extracted by a procedure known as hydraulic fracturing, or "fracking." Extractors inject a mixture of acids, water, gasses, and other additives under high pressure into the bore hole to fracture the bedrock, thus releasing the natural gas. After fracturing is complete, workers recover a portion of the injected fluid, called flowback, and store it in open pits

▲ Sampling tank-stored fracking fluids. *Pam Edwards, Forest Service*

or tanks. Because flowback often has high chloride concentrations, proper characterization of flowback chemistry is important to safe disposal. Forest Service scientists, in cooperation with Berry Energy Corporation, tested two technologies that measure chloride concentrations and determined that the concentrations increased with the depth in the tank. They also found that laboratory analyses were more accurate than field test kits.

Lead: Northern Research Station

Profile in Science—
Charlie Crisafulli

Volcano's eruption jumpstarts decades of disturbance studies

▲ Charlie Crisafulli, Forest Service Scientist. *Forest Service*

Within 2 months of Mount St. Helens' catastrophic eruption on May 18, 1980, Charlie Crisafulli was on the ground conducting research. Crisafulli has been at the volcano ever since, leading studies that are providing insights into the initial and long-term responses of ecosystems to large, infrequent disturbance.

As a research ecologist with the Pacific Northwest Research Station of the Forest Service, and as the agency's lead scientist at the volcano, Crisafulli conducts research on the ecology of the volcano's plants, animals, and fungi. His findings are helping to advance understanding of how ecosystems respond to major environmental disturbances.

Crisafulli grew up in the Hudson River Valley south of Albany, NY, earned a bachelor's degree in biology from the State University of New York, and then let wanderlust take him west. He was a Utah State University research associate when he started working at Mount St. Helens. He joined the Forest Service in 1989. His three decades of research have revealed that chance events, such as the season and time of day a disturbance occurs, play a significant role in determining an ecosystem's response. Crisafulli found that the most important factors determining the pace of ecological response are the type, amount, and distribution of living and dead organisms remaining at a site after a disturbance event.

Crisafulli has documented some of his Mount St. Helens findings in scientific papers. He and his Forest Service colleague, Fred Swanson, together with plant ecologist Virginia Dale from Oak Ridge National Laboratory in Tennessee, jointly edited a book titled Ecological

Responses to the 1980 Eruptions of Mount St. Helens, which was published in 2010. Crisafulli wrote or co-wrote 11 of the book's 20 chapters.

Research conducted at Mount St. Helens after it erupted changed some scientific thinking about the consequences of disturbance. The element of chance plays a big role. Northern pocket gophers and other small rodents endured because they were underground during the 1980 eruption. Gophers have since built miles of tunnels that initially helped plants and other animals colonize the area. To monitor the changes, Crisafulli and other researchers set up plots around the mountain. Crisafulli studies amphibians more extensively than other forms of life.

"Salamanders, frogs, and toads intrigue me because they straddle both land and water," Crisafulli said. As it turns out, ice-covered lakes protected many amphibians near Mount St. Helens in 1980 and some have absolutely flourished since the eruption.

Crisafulli is now collaborating with Government officials and researchers interested in establishing similar long-term ecological study plots in Chile, on Chaitén, which erupted in 2008; in China, on Wudalianchi, which erupted in 1719; and in Alaska, on Kasatochi, which erupted in 2008 on the Aleutian Islands chain.

Crisafulli recently received the 2011 U.S. Department of Agriculture Secretary's Honor Award for Personal and Professional Excellence in recognition of his extraordinary efforts to communicate the significance of long-term scientific research at Mount St. Helens to scientists, policymakers, and the public.

Water, Air, and Soil

Ozone Measured at Higher Elevation in the White Mountains Than in Any Previous Studies

New data will help scientists understand long-term trends in ozone concentrations in North America

A new study provides first measurements of surface ozone concentrations in the White Mountains of California, including the two highest sampling elevations (4,342 and 3,783 meters) ever reported for a North American study, for summer season 2009. Measured ozone concentrations in this study, conducted in cooperation with St. Mary's College, Moraga, CA, were in rough agreement with results from other high-elevation sites in Europe, Asia, and North America, and the general elevation-based trends observed were mostly consistent with results from other alpine locations from around the globe. The researchers found high ozone concentrations at the summit of White Mountain to correlate with slow-moving back trajectories that have spent more time inland and less time off shore, whereas low ozone concentrations were associated with fast-moving back trajectories that had limited exposure to polluted inland air. This finding will help in understanding long-term trends in changes of ozone concentrations in North America and long-range transport of air pollution across the Pacific from the Asia.

Lead: Pacific Southwest Research Station

▲ Passive samplers for monitoring ozone and nitrogenous air pollutants at the White Mountains Summit. *Andrzej Bytnerowicz, Forest Service*

▲ View of the White Mountain Summit (4,342 m elevation) of the White Mountains Wilderness, where air pollution monitoring was conducted in summers of 2009 and 2011. *Andrzej Bytnerowicz, Forest Service*

▲ (L–R) St. Mary's College students Chris Beck and Blanka Auble, St. Mary's College professor of chemistry Dr. Joel Burley, and Pacific Southwest Research Station senior scientist Dr. Andrzej Bytnerowicz at the White Mountains Summit (4,342 m elevation) after installing the UV-absorption ozone monitor. *Scott Cole, UC White Mountains Research Station (used with permission)*

Global Forests Sequester One-Third of Annual Fossil Fuel Emissions

Forested land plays a much larger role in removing carbon from the atmosphere than was previously thought

Global forests annually removed 2.4 billion tons of carbon (8.8 billion tons of carbon dioxide) from the atmosphere, about one-third of annual fossil fuel emissions, from 1990 to 2007. This forest carbon sink (the net gain of carbon by forests) is found on every continent on Earth. The size of the sink varies over time and by region. Understanding the location of the current sink, and the wide range of mechanisms responsible for it, is an important step toward understanding Earth's changing climate system. An international team of scientists from 14 institutes, led by two Forest Service scientists, estimated the global forest carbon sink based on millions of on-the-ground measurements in forests around

the world. The study reveals the dominant role of tropical forests in the exchange of carbon between the land and atmosphere and illustrates the importance of reducing tropical deforestation to limit the buildup of atmospheric carbon dioxide. The study also highlights the risk of passively relying on forests to continue to remove carbon from the atmosphere, for such carbon sequestration can be reversed by increased drought, wildfires, and forest degradation. Research partners include Peking University; Woods Hole Research Center; University of Helsinki; Canada Forest Service; University of Leeds, United Kingdom; International Institute for Applied Systems Analysis, Austria; Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia; Laboratoire des Sciences du Climat et de l'Environnement, France; Duke University; Princeton University; U.S. Geological Survey; and Oak Ridge National Laboratory.

Lead: Northern Research Station

▲ Forest interior in a permanent plot in Amazonian Peru; note the buttressed tree being measured at 5 meter with the help of a ladder. *Monteagudo-Mendoza, University of Leeds, UK (used with permission)*

Science Solution

Technology Supports Resource Management Decisions in a Changing Climate

Managers welcome new technology in forest planning efforts

▲ Elizabeth Agpaoa, Forest Service Regional Forester. *Forest Service*

The Template for Assessing Climate Change Impacts and Management Options, or TACCIMO, is a Web-based tool designed to bring the best climate change science to decisionmakers and planners in a simple and usable format. The Forest Service's Southern and Eastern Regions and, most recently, the Pacific Southwest Region have adopted this new technology to address climate change from a science perspective.

Climate change is an enormously complex issue with implications spanning multiple resource areas and geographic scales. New climate change knowledge, including impacts and management options, emerges daily, and TACCIMO provides additional science-based information necessary to make informed decisions. The emergence of this multidiscipline, multiscale, and rapidly changing problem necessitates the development of new technology to support information needs during resource management, planning, and decisionmaking. The suite of tools enables users to review climate change forecasts, consider effective management options, and generate customized reports that assist with long-term forest sustainability.

"When it comes to developing new technology, no substitute exists for involving users from the very beginning," said Forest Service Regional Forester Elizabeth Agpaoa. "They, more than anyone, know what is needed to get their job done and what is required to do it better."

TACCIMO's iterative and interactive development process resulted in a condensed, concise, and credible tool for planning and assessment, given its first full deployment earlier this year to help the forest plan revision process for the George Washington National Forest in the Appalachian Mountains. Work on preparatory phases, such as preloading scientific and management data, and training and orientation, has since expanded on Forest Service land in the Eastern United States and in California. Although the tool's development is still underway, Agpaoa recognized the TACCIMO team, composed of Southern Region planners and Southern Research Station scientists, with a Technology Transfer Award for the "model interaction" between research and forest management staff. The team continues to expand and refine the tool to better meet the needs of eastern and western resource managers.

Water, Air, and Soil

Framework Identifies Tree Species Most at Risk From Climate Change and Other Threats

Forest Service project helps managers prioritize threatened tree species for management and conservation

A variety of threats, most importantly climate change and insect and disease infestation, will increase the risk that forest trees could experience population-level or species-level extinction. Species, however, differ in important traits, such as life history strategies and population dynamics, that could drive widely varying responses to potential threats. Determining how to prioritize species for management and conservation activities in the face of these threats will pose a particular challenge in species-rich regions. To address this challenge, a North Carolina State University scientist in cooperation with the Southern Research Station Eastern Forest Environmental Threat Assessment Center developed a framework that enables managers to assess the relative risks of genetic degradation to forest trees affected by multiple threats. Known as the Forest Tree Genetic Risk Assessment System (ForGRAS), the framework is in use at the Forest Service Southern and Pacific Northwest Regions to identify species at risk as a step toward developing management plans. ForGRAS is a flexible approach, allowing application at multiple scales and across any area for which data exist on the population dynamics and distribution of the species of interest. ForGRAS information and materials are available at http://www.forestthreats.org/current-projects/project-summaries/genetic-risk-assessment-system.

Lead: Southern Research Station

▲ A brook flowing through the White Mountains of New Hampshire. *Ken Dudzik, Forest Service*

▲ Forested ecosystem in the White Mountains of New Hampshire. *Ken Dudzik, Forest Service*

Determining What Levels of Air Pollution Harm U.S. Ecosystems

Research provides an assessment tool for managers and policymakers to use when making decisions about limiting nitrogen pollution to protect vulnerable ecosystems

Nitrogen (N) deposition from air pollution has reached a level that has caused, or is likely to cause, alterations and damage in ecosystems across the United States. An international team led by a Forest Service scientist determined the critical N load, that is, the level of N deposition below which no detrimental ecological effects occur. The team synthesized current research relating atmospheric N deposition to effects in terrestrial and aquatic ecosystems. Responses to increased N deposition included changes in biological community structure, altered soil N cycling, increased N leaching to soil and surface waters, increases in susceptibility to secondary stresses, increases in invasive species, and altered fire regimes. The range of critical loads for nutrient N reported for U.S. ecoregions, inland surface waters, and wetlands is 1 to 39 kg of N/ha annually. In many regions, the critical load for sensitive receptors has been exceeded. The critical loads approach is an ecosystem assessment tool with great potential to simplify complex scientific information and provide a scientific basis for making decisions about limiting air pollution to protect vulnerable ecosystems. Research partners include U.S. Geological Survey; U.S. Environmental Protection Agency; Cornell University; Syracuse University; University of California at Riverside; B-WARE Research Center, the

Netherlands; University of Colorado; Centre for Ecology & Hydrology (CEH), United Kingdom; Marshall University; Arizona State University; University of Michigan; and Cary Institute of Ecosystem Studies.

Lead: Northern Research Station

Science Helps Conserve Tropical Montane Cloud Forests

Unique forests are sources of clean water and hotspots of biodiversity

In the late 1980s, scientists realized that tropical montane cloud forests were important sources of water and

Profile in Science—Christina Liang

The tortoise and the research ecologist

Toads and tortoises, be forewarned: You are being tracked. Christina Liang, a research ecologist with the Forest Service Pacific Southwest Research Station, says that tracking wildlife tells us a lot about how it lives and its interaction with the environment.

Liang, who is stationed in Hilo, on the Big Island of Hawaii, with the station's Institute for Pacific Islands Forestry, first tracked animals in 1994 while doing a Student Conservation Association internship in St. George, UT. While there, she spent the spring field season with the National Biological Service (now part of the U.S. Geological Survey) tracking desert tortoises by following radio transmitters attached to their shells. Her fieldwork was part of a long-term monitoring program designed to determine population trends for this threatened species.

"The wildflowers were just spectacular that year, and there was so much diversity and movement of wildlife," Liang said. "That cemented my interest in environmental studies and ecology."

Later in her career, she tracked Yosemite toads, a California endemic species of special concern, in the Sierra National Forest. Liang found that the toads travel far from their breeding area—up to 1.26 kilometers—and favor open environments. In California, the Forest Service currently uses her findings to better manage the toad's habitat by setting buffers around its breeding areas in wetland meadows.

"As an ecologist, one of the things that drives me is curiosity about the natural environment," Liang said. "I am interested in why things are the way they are, the relationships between species and with the environment."

Liang did not start out as a typical outdoors mountain woman. Her family did not camp, so sleeping in the woods was not something she was exposed to until she was in college. It was her junior year as an

▲ Christina Liang, Forest Service Ecologist. *Forest Service*

integrative biology major at the University of California, Berkeley, that changed her focus and led her into a career as a research ecologist. She spent that year abroad in Australia taking biological and field courses.

"That's when I really started getting into the outdoors," Liang said. "It was an eye-opener. I thought, 'Wow, look at all this cool stuff.' There are such amazing wildlife and natural areas in Australia."

Liang sees similar ecological uniqueness in Hilo, where she has been stationed since October 2011. She is currently studying the coqui frog, a nonnative invasive species that was accidentally introduced into Hawaii from Puerto Rico more than 20 years ago. Known for its noisy mating call, the frogs pose a threat to Hawaii's island ecosystem. Coqui frogs have a voracious appetite, threatening Hawaii's unique insects and spiders, in addition to potentially competing with endemic birds and other native fauna that rely on insects for food.

"Hawaii has no native amphibians, and the establishment of these species on the islands has potential ecological impacts on native food webs and ecosystems," Liang said. "I'm looking at understanding conditions that support higher densities of frogs and the ecological impact of various densities in Hawaiian forests."

Water, Air, and Soil

▲ Tropical montane cloud forest from the Luquillo Experimental Forest, Puerto Rico. *Ivan Vicens and Gerald Bauer, Forest Service*

▲ Understory of tropical montane cloud forest in Puerto Rico. Hazy light in background is from clouds at surface level. *Gerald Bauer, Forest Service*

remarkable hotspots of biodiversity. These evergreen forests have a persistent or seasonal cloud cover, usually at the canopy level, and often exhibit an abundance of mosses on the ground and vegetation. The scientists also recognized that these special forests were being deforested rapidly and the scientific basis for managing them was lacking. At that time, the International Institute of Tropical Forestry of the Forest Service undertook a special effort to develop the scientific understanding necessary to manage these unique forests. The Institute collaborated with international

▲ Dr. Peter Weaver and Luis Omar Ortiz visit a typical stand of montane cloud forest in Puerto Rico. *Ivan Vicens, Forest Service*

▲ Tropical montane cloud forest from the Luquillo Experimental Forest, Puerto Rico. *Ivan Vicens and Gerald Bauer, Forest Service*

researchers to complete research needed to better manage and conserve tropical montane cloud forests. The recent publication of 72 papers in an International Institute of Tropical Forestry-sponsored publication demonstrates that scientists now have the basic understanding needed to manage and conserve these forests. Among the outcomes of this research is that the United Nations and many international organizations have formally recognized the importance of these forests. Consequently, deforestation rates have declined, and governments have established numerous tropical montane cloud forest reserves and begun to manage them in a sustainable manner. The effort represents an excellent example of how the research process can effectively develop the information needed to sustainably manage forests. This project was conducted in partnership with the University of Pennsylvania.

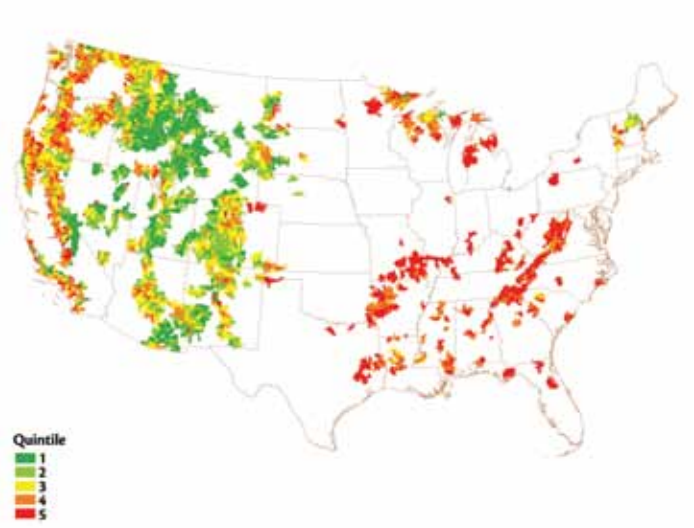
Lead: International Institute of Tropical Forestry

Watersheds on National Forests Given High Marks

Researchers seek to understand how the risk of water quality impairment from nonpoint sources such as roads and farms varies across watersheds containing lands of the NFS

Annual Gallup polls over the past decade have consistently found the pollution of rivers, lakes, reservoirs, and drinking water to be the environmental problems of greatest concern to Americans. Since passage of the Clean Water Act in 1972, considerable progress has been made in controlling pollution of the Nation's freshwaters. However, most successes have been with point sources of water pollution, such as factories and municipal wastewater treatment plants. Progress in controlling pollution from nonpoint sources, such as farms or roadways, has lagged behind. Given the continuing concern about nonpoint-source pollution, Forest Service researchers at the Rocky Mountain Research Station sought to understand how the risk of water quality impairment from nonpoint sources varies across the nearly 3,700 fifth-level watersheds in the United States containing lands of the NFS. The researchers assessed the risk based on comprehensive nationwide data sets for a series of watershed stressors and resources at risk. Findings show that the non-NFS areas of the watersheds are consistently under much greater stress than the NFS areas, but that the resources at risk are more evenly spread across the NFS and non-NFS areas of the watersheds. Moreover, the results show that risk is spread unevenly across the NFS, with most units in the two eastern regions at higher risk than nearly all units in the western regions. The substantial difference in risk of impaired watershed condition on NFS as opposed to non-NFS lands offers strong evidence that ecosystem processes and the goods and services that flow from these processes are under reduced risk on public lands, even if those lands are managed for multiple uses. Given the increase in development of private lands that is expected as the U.S. population continues to grow, the difference in risk of impaired watershed condition between public and private lands is likely to grow, thus increasing the value of the protected lands. This research offers a starting point for decisions on risk mitigation efforts, one that could be supplemented by locally available data on additional indicators and by a comparison of the costs and benefits of mitigation options. This assessment also provides consistent data for others to use in national or regional watershed analyses. More information about this research is available at http://www.treesearch.fs.fed.us/pubs/36948.

Lead: Rocky Mountain Research Station



▲ The degrees of risk for nonwilderness NFS parts of 3,700 watersheds (1, low risk; 5, high risk). *Tom Brown, Forest Service*

Science Solution

Wisconsin Town Saved From Termites by Forest Service Scientists

Homeowners saved tens of thousands of dollars

Rachel Arango knows her bugs. As an entomologist for the Forest Service's Forest Products Laboratory, Arango and her colleague Rick Green helped purge one small Wisconsin town, Endeavor, of its large termite population, ultimately saving its citizens tens of thousands of dollars while restoring their peace of mind.

Using a novel community-wide approach—a combination of environmentally sensitive treatments and applications over several years—Arango and Green collaborated with private businesses, local citizens, and State agencies to combat this tenacious pest. Because of their work, the number of reported termites in Endeavor dropped very quickly after the first year, and researchers have detected no termite activity since fall 2009.

Endeavor is a struggling but determined village of about 450 people in central Wisconsin. Citizens first noticed termite activity in the mid-1980s; the initial infestation was likely because of stowaway insects on railroad ties or some other imported timber. Although particular

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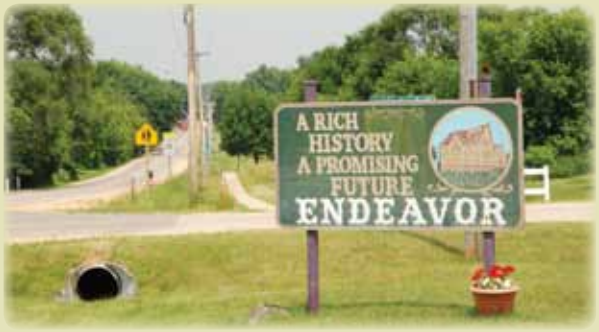


▲ Endeavor, WI, town entrance. *Rebecca Wallace, Forest Service*

districts in large metropolitan areas, such as the French Quarter in New Orleans, have been the focus of extensive ongoing termite bait programs, the project in Endeavor is an otherwise unique case of the communitywide eradication approach in the United States. The relatively isolated location and confined nature of the five distinct termite colonies, which included tens of thousands of bugs in and around the village center, made Endeavor an ideal candidate for communitywide eradication efforts.

Drawing on a history of termite research established by their retired colleague, Glenn Esenther, Green and Arango developed a three-stage eradication program in coordination with Randy Kalk and Dan Keohane of Alternative Pest Solutions in Madison and Phil Pellitteri of the University of Wisconsin–Madison's entomology department.

The research team employed the most ecologically friendly methods for detection and treatment of termites, using the least amount of toxic chemicals possible. Eradication, it is hoped, will improve property values and provide other long-term benefits for the residents of this economically depressed rural community.

The financial savings per household for citizens of Endeavor is difficult to estimate with such a communitywide approach, Kalk said. Endeavor homeowners have likely saved tens of thousands of dollars in repair costs by participating in this project.

Estimates put damage and subsequent repair costs from termite infestation nationwide at about $11 billion annually. Termite treatment for the average homeowner costs about $1,000 to $2,000 per property for initial treatment, Kalk said. Necessary ongoing treatments cost an additional $300 to $500 per year and can go on indefinitely. Expenses vary depending on the size of the treated structure. Repair costs to address previous damage can be thousands more.

For this project, Green and Arango acquired bait stations through the Forest Products Laboratory, and placed them initially only on city property. Eventually, all Endeavor homeowners were eligible to participate. Those who elected to receive treatment were covered by an arrangement through the village administration, which paid a total of $3,493 annually from 2006 to 2009 for treatment and monitoring services throughout the village.

The town's location of about 43.7°N latitude, 100 miles north of where termites are typically found, affords an ideal combination of climatic, geologic, and hydrologic conditions for these destructive insects to thrive. Impending changes in global climate patterns may eventually allow for natural migration of colonies further north, making eradication research at the community level all the more important. Green and Arango avoided traditional chemical-intensive management methods in Endeavor because of the potential for contamination of the town's shallow water supply and adjoining river basin.

Community education efforts throughout the project involved newsletter supplements describing what termite activity looks like and how to distinguish termites from ants. Continuing voluntary bait station observation and reporting by Kalk in 2010 and 2011 will continue indefinitely. Although this project has been ongoing for 5 years, the underground nature of most termite activity makes it difficult to say that the problem is completely solved.

These persistent pests "are much more clever than we initially thought," Arango said. Thanks to the collaborative efforts of local citizens, private business, State agencies, and Federal researchers, the termite may well have met its match.

▲ Typical termite bait station. *Rebecca Wallace, Forest Service*

Wildlife and Fish

The **Wildlife and Fish** SPA relies upon interdisciplinary research to inform policy initiatives affecting wildlife and fish habitat on private and public lands and the recovery of threatened or endangered species. Scientists in this program area investigate the complex interactions among species, ecosystem dynamics and processes, land use and management, and emerging broad-scale threats, including global climate change, loss of open space, invasive species, and disease.

Conservation Priorities Identified for Northwest Amphibians and Reptiles

Heightened awareness leads to a tri-agency conservation strategy for the Siskiyou Mountains salamander

At a reptile conservation conference, scientists and natural resource managers from across western Canada and the United States synthesized conservation concerns and priorities for 105 species of amphibians and reptiles. They identified key threats to these species and found that a lack of basic ecological knowledge, insufficient funding, and limited communication regionwide hindered management. These species of concern would likely benefit from having standardized regulations for managing native and nonnative species; increased use of data management programs; and jurisdictional stewards to serve as liaisons among fisheries, wildlife, and forestry departments. This heightened awareness of herpetological conservation has resulted in several new conservation partnerships in the Northwest. In Oregon, for example, three Federal agencies are implementing a conservation strategy for the Siskiyou Mountains salamander on Federal lands. The U.S. Fish and Wildlife Service is using this strategy for another salamander species in New Mexico. Cooperators in this effort include the Pacific Southwest Research Station; USDA Natural Resources Conservation Service; U.S. Department of the Interior, Bureau of Land Management, U.S. Geological Survey, U.S. Fish and Wildlife Service; British Columbia Ministry of the Environment; Oregon Department of Fish and Wildlife; Montana Natural Heritage Program; Wyoming Natural Diversity Program; University of Wyoming; Idaho Department of Fish and Game; Washington Department of Fish and Wildlife; Alberta Conservation Association; National Center for Conservation Science and Policy; E. Wind Consulting; Weyerhaeuser Co.; Longview Timberlands; Idaho State University; University of Alaska Southeast; University of Washington; Oregon State University; and Quest University, British Columbia, Canada.

Lead: Pacific Northwest Research Station

A Case Study of California Fisher

Researchers use landscape trajectory analysis to evaluate management risks

Ecosystem management requires an understanding of how landscapes vary in space and time, how this variation can be affected by management decisions or stochastic events, and the potential consequences for species. Landscape trajectory analysis, coupled with a basic knowledge of species habitat selection, offers a straightforward approach to ecological risk analysis and can be used to project the effects of management decisions on species of concern. The fisher (*Martes pennant*) occurs primarily in late successional forests, which, in the Sierra Nevada mountains, are susceptible to high-intensity wildfire. Understanding the effects of fuels treatments and fire on the distribution of fisher habitat is a critical conservation concern. Researchers assumed that the more a treated landscape resembled occupied female fisher home ranges, the more likely it was to be occupied by a female, therefore lowering the risk to the population. Thus, researchers characterized important vegetation attributes within the home ranges of 16 female fishers and used the distribution of these attributes as a baseline against which the effects of forest management options could be compared. They used principal components analysis to identify the major axes defining occupied female fisher home ranges and these axes, in addition to select univariate metrics, became the reference for evaluating effects of landscape change. Researchers demonstrated the approach at two management units on the Sierra National Forest by simulating the effects of both no action and forest thinning, with and without an unplanned fire on vegetation characteristics, over a 45-year period. Under the no-action scenario, landscapes remained similar to reference conditions for approximately 30 years until forest succession resulted in a loss of landscape heterogeneity. Comparatively, fuel treatment resulted in the reduction of certain forest elements below those found in female fisher home ranges yet little overall change in habitat suitability. Adding a wildfire to both scenarios resulted in divergence from reference conditions, although in the no-action scenario the divergence was four times greater and the landscape did not

recover within the 45-year timeframe. These examples demonstrate that combining the results of forest growth and disturbance modeling with habitat selection data may be used to quantify the potential effects of vegetation management activities on wildlife habitat.

Lead: Pacific Southwest Research Station

How Large-Scale Forest Conditions Influence Northern Goshawk Nesting

A collaborative research-management project enhanced efforts to understand nesting habitat requirements

The northern goshawk is a forest-sensitive species in northern Wisconsin. Forest Service scientists, in cooperation with Landcare Research, New Zealand, analyzed 10 years of nest survey data from the Chequamegon–Nicolet National Forest and found that the key determinant of goshawk nest occurrence was the ratio of conifer cover to aspen–birch cover surrounding a potential nest site. Goshawks are woodland raptors that use a variety of forest types for nesting, making it difficult to determine nesting habitat requirements at the regional level. The hawks are associated with mature forests with large trees and open understories, but they may select nesting locations as close as possible to foraging habitats. Forest Service scientists, in partnership with the Chequamegon–Nicolet National Forest, examined how landscape-scale forest composition and road density at several different distances from nest sites and random locations throughout the forest influenced goshawk nesting presence. Nest survey and monitoring data from 1997 to 2006 indicate more conifer cover and less aspen-birch cover and fewer primary roads in the areas surrounding nests. The key driver is the ratio of conifer cover to aspen-birch cover surrounding a potential nest site. These results are extremely useful in sustaining populations throughout the forest.

▲ Adult goshawk in northern hardwood stand in Chequamegon–Nicolet National Forest. *Forest Service*

Lead: Northern Research Station

Scientists Model How Priority Bird Species Occupy Riparian Buffers

Study provides important cost and benefit information to the forest industry and Federal agencies actively managing lands for both timber production and wildlife diversity

Land managers often retain riparian buffers, areas or zones of mature forest, along streams in managed forest landscapes. Managers often need to balance the costs of the reduced timber production associated with larger buffer zones with the ecological benefits of leaving wider buffers for interior forest birds. The interaction of buffer width and age of surrounding pine plantations on habitat use by birds, however, is not well understood. Scientists with the Southern Research Station, in cooperation with Weyerhaeuser Company, National Council for Air and Stream Improvement, and University of Arkansas at Monticello, modeled probability of occupancy for 16 bird species of regional conservation importance in the Ouachita Mountains of Arkansas in riparian buffers of varying width surrounded by pine plantations in three different age classes. Occupancy models included a positive association with buffer width for nine bird species associated with mature forests, but most species traditionally associated with mature forests were common in narrow riparian buffers regardless of width. Models for three early successional species—those usually occupying young, relatively open forests—indicated that they were less likely to occupy a wider buffer area. Researchers found diverse responses among species to width of riparian buffers in relation to the age of adjacent plantations; some species benefited from wide riparian buffers, while others benefited from narrow buffers. Thus, the optimal width of riparian buffers for bird species conservation depends on which species the manager is most interested in conserving. This study provides important cost and benefit information to forest industry and Federal agencies actively managing lands for both timber production and wildlife diversity.

Lead: Southern Research Station

Hydrodynamic Modeling Determines How the Pattern of Water Released From Hydropower Plants Affects Frog Eggs and Tadpoles

Information can reduce the negative effects of water flow on sensitive species in regulated rivers

In regulated rivers, relicensing of hydropower projects can provide an opportunity to change flow regimes and reduce negative effects on sensitive aquatic biota. Volume of flow, timing and ramping rate of spring spills, and magnitude of aseasonal pulsed flows have potentially negative effects on the early life stages of amphibians such as the foothill yellow-legged frog (*Rana boylii*). Two-dimensional hydrodynamic modeling is one method of evaluating potential effects of

Profile in Science—Lee Cerveny

Humans and nature and the nature of humans

▲ Lee Cerveny, Forest Service Social Scientist. *Forest Service*

Forest Service social scientist Lee Cerveny has carved out a special niche in the world of research. While her colleagues go into national forests and other protected areas to study things like trees and wildlife, she enters these natural environments to study humans—how they interact with and use a range of sites and resources.

She recently launched the Human Ecology Mapping Project, a multiyear study to understand and map human activities and values in the forests of Washington's Olympic Peninsula. Using a series of community workshops, the mapping project will identify and display the diversity of recreational, cultural, historical, and economic connections held by a variety of agencies, tribes, resource users, and residents. The maps are digitized and analyzed using Geographic Information System tools to reveal existing patterns, such as high-intensity sites, areas of overlapping use indicating potential for resource conflict, and treasured places with barriers to access.

Land managers may need to accommodate the needs of visitors engaged in a variety of forest activities, such as organized equestrian rides, competitive trail-running events, commercial mushroom picking, and backpacking. The mapping protocol can examine sociospatial aspects of very specific issues. For example, a recent project identified places where forest safety is a concern for Latino brush harvesters and hunters. The Human Ecology Mapping Project will provide information showing managers where these important use areas exist and where they overlap, potentially helping planners to manage public lands better.

"These sociocultural data layers can be integrated with biophysical data layers for use in various types of planning," Cerveny said. "By understanding changing patterns of resource use and human activity area wide, national forest planners can make informed decisions about their own management units. This project offers land managers a valuable tool for understanding the variety of ways Americans interact with forests through outdoor employment, recreation, historical ties, cultural connections, and ecological values."

Cerveny's other research theme is the dynamics of natural resource institutions. With its specialized language and practices, a research institution might not seem all that different from a tribe in a remote corner of the world; and, to Cerveny, it is not. She approaches her study of institutions and organizations in the same way as she would a tribe—recognizing its unique set of symbols, rituals, structures, and meanings. In one recent study, she helped improve the interactions and knowledge sharing between recreation scientists and land managers, which are critical in solving recreation and management problems.

Cerveny identified institutional factors that promote healthy interactions and information sharing. "Never undervalue the importance of face-to-face communication and personal ties between managers and scientists. Managers and researchers benefit from working together to identify resource problems, seeking information and crafting solutions that are actionable."

Recently, Cerveny has turned her attention to focus on Forest Service partnerships and their role in resource management. Because Cerveny's work has helped the Forest Service adapt to social and economic change, she is in high demand as a research collaborator inside and outside the agency. Cerveny is currently collaborating with four universities, two national forests, two research station teams, and one nonprofit organization on two of her recent studies. She works out of the Forest Service Pacific Northwest Research Station in Seattle, WA.

flow variation on frog egg masses and tadpoles. Forest Service researchers, in cooperation with University of California, Davis, explored the usefulness of this technique by modeling habitat suitability under several pulsed flow scenarios in two river reaches in northern California. The study conducted analyses beyond simple weighted usable area calculations, such as quantifying the risk of scour or stranding, to quantify potential loss under different flow scenarios. The modeling results provided information on potential susceptibility to flow fluctuations as well as the influence of channel morphology on habitat suitability. Under each flow scenario, low percentages of suitable habitat remained suitable or were buffered from the pulse, creating high potential for scour of egg masses or tadpoles. However, due to differences in channel morphologies, the wide, shallow study site provided two to three times the buffering capacity of the entrenched study site. Additional analyses suggested that limited buffering capacity and lack of connectivity between suitable egg mass and tadpole habitats might explain why some hydraulically suitable habitats are unoccupied. This type of model-based analysis would be useful for managing foothill yellow-legged frogs or similar aquatic species in regulated river systems.

Lead: Pacific Southwest Research Station

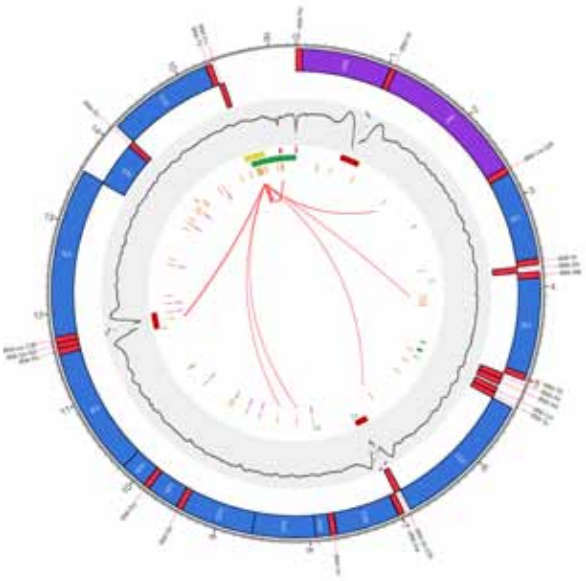
▲ Foothill yellow-tailed tadpoles. *Sarah Kupferberg, U.C. Berkeley (used with permission)*

Genetic Studies Reveal Population Structure of Fisher Predate Current Management Practices

Scientists borrow technologies from the Human Genome Project to study a forest-dwelling mammal

Technologies initially motivated by the Human Genome Project have been modified to bring affordable genomics to conservation genetics. Using this technology, Forest Service scientists in the Pacific Northwest Research Station, in cooperation with Rocky Mountain Research Station, sequenced entire mitochondrial genomes from 40 fishers—a forest-dwelling mammal that is part of the weasel family. Previous research, based on a portion of the mitochondrial genome, observed such low levels of genetic variation within fishers that individuals from the Great Lakes Region and Pacific West appeared identical. The entire mitochondrial genome sequences provided sufficient information to support taxonomic subspecies, as well as identify unique populations. These results indicate that the observed genetic structure represents a pattern that has been in place for thousands of years, much longer than current land management practices. Recent petitions have sought to have distinct population segments of fisher listed under the Endangered Species Act (ESA), and conclusions from this proposed listing are pending. Management decisions about whether these populations warrant protection under the ESA are taking this research into account. Scientifically informed management decisions regarding fishers are now possible, whereas in the recent past, technical information about the fisher was limited.

Lead: Pacific Northwest Research Station



▲ New technologies enable researchers to identify genetic differences within a species (for example, identifying populations from different regions). This diagram of the fisher mitochondrial genome shows the location of genes (blue, red, purple) and variable nucleotide positions (tick marks, inner circle). *Richard Cronn, Forest Service*

Fire and Fish Dynamics in a Changing Climate

Forest Service scientists are seeking a better understanding of how climate change and fire affect native trout

Wildland fire affects native fishes in the Rocky Mountain West by removing riparian vegetation, which increases solar radiation to the stream and leads to warmer summer water temperatures. Many native fish, such as bull trout and cutthroat trout, evolved

with fire, and their populations are resilient to fire's effects if habitat is otherwise unaffected or if the movement of fish from nearby, robust populations is ongoing. Stream habitat fragmentation and degradation and the invasion of nonnative fishes, such as brook trout and brown trout, that tolerate warmer water temperatures, however, have reduced this resiliency. Climate change may further weaken this resiliency in two ways: by directly increasing water temperatures and by changing the influence of fire. Thus, forecasting the persistence of native trout undergoing climate change requires an understanding of fire dynamics—including size, distribution, frequency, severity, and the influence of fuels management—and the responses of nonnative fish species. To evaluate fire and fish population dynamics, researchers at the Rocky Mountain Research Station, in collaboration with the University of Montana, are linking the landscape fire succession simulation model Fire-BGCv2 with a stream temperature model and trout growth models to predict changes in trout species distributions and productivity in the East Fork Bitterroot River basin in Montana. This basin has a history of large, stand-replacing fires, yet still supports native fish populations in many tributaries. Using model predictions, the researchers will evaluate potential thresholds in fire risk, such as those related to the persistence of federally listed bull trout, and the scales at which to expect recovery under various climate and fire regimes. To initiate their study, researchers first precisely modeled stream temperature based on a suite of climatic and geomorphological variables. They then linked the stream temperature model to a version of the Fire-BGCv2 model calibrated to the East Fork Bitterroot River basin and are presently running model simulations for the following scenarios:

1. Historical climate—with historical fire regime and with fire exclusion

▲ Male bull trout in the East Fork Bitterroot River Basin. *Aubree Benson, Forest Service*

2. Future warm/wet climate—with fire exclusion and with fuels management
3. Future hot/dry climate—with fire exclusion and with fuels management

Each scenario will produce a time series on stream temperature and fire disturbance characteristics that researchers can use to estimate the amount and suitability of habitat for native and nonnative trout. The researchers' goal is to develop an understanding about those fire and landscape characteristics that pose higher risks for native trout species. For example, the researchers expect the probability of bull trout persistence to vary under each scenario as a function of increasing fire frequency, magnitude, and severity. If true, this will help identify those tributaries where it is best to focus bull trout conservation efforts. In addition, the researchers will evaluate which factors, such as fire severity, fire size, vegetation, or fuels, result in large-scale, long-term changes in fish communities. Finally, they will evaluate the effectiveness of fuels management, through its influence on fire dynamics, in promoting the persistence of native trout populations.

Lead: Rocky Mountain Research Station

Science Solution

Urban Planners Benefit From LiDAR Analysis of Tree Canopies

Canopy assessments have been completed for more than 300 communities

TTrees in cities may not look like parts of a typical forest, but they do provide valuable ecosystem services to urban and suburban dwellers. Tree canopies cool sidewalks and buildings, reducing the heat island effect, saving energy, and reducing air pollution. They also improve water and air quality, provide wildlife habitat, make neighborhoods more livable, and provide psychological benefits for human and other residents; for example, New York City's

▲ Automated processing of LiDAR data can be used to map urban ecosystems with incredible detail, giving resource managers access to accurate information on the amount of existing tree canopy in addition to the amount of land available to plant trees. *Jarlath O'Neil-Dunne, University of Vermont (used with permission)*

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Inventory and Monitoring

The **Inventory and Monitoring** SPA provides the resource data, analysis, and tools needed to identify current status and trends of forests; management options and impacts; and threats from fire, insects, disease, and other natural processes, thus enhancing the use and value of our Nation's forests and grasslands. Assessing current and potential effects of climate change depends on the monitoring of forest ecosystems at greatest risk to rapid change. Focus areas include the development and use of integrated interdisciplinary science, technologies, and remote sensing to increase the timeliness and spatial resolution of incidence of forest fragmentation, insect outbreaks, diseases, fires, and extreme weather events.

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Central and Prospect Parks are havens for migrating birds as much as for New Yorkers.

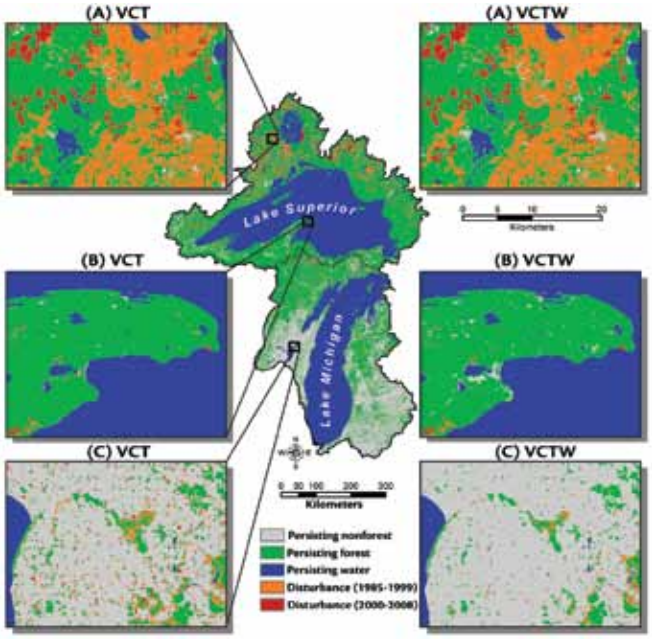
An important part of setting realistic tree planting goals is measuring and evaluating current urban forests. The term "urban tree canopy" describes the layer of leaves, branches, and stems of trees that cover the ground when viewed from above. Forest Service scientists have developed techniques to analyze and prioritize canopy data so that urban planners and parks departments can focus their efforts on locales that will benefit most from tree planting. Although aerial and satellite images can now show amazing detail, using reflected light to map the canopy in urban areas has substantial shortcomings; for example, trees can be totally obscured by building shadows. A technology similar to radar—LiDAR, or light detection and ranging, invented over 20 year ago—can overcome these limitations. LiDAR sensors emit their own near-infrared energy in a focus beam of laser light, which is not sensitive to shadows, and LiDAR data can estimate the height of features to within a few centimeters. Using advanced processing algorithms, scientists can extract detailed estimates of the current tree canopy and find new locations to plant trees.

In 2005, Forest Service researchers at the Northern Research Station—Morgan Grove and Jarlath O'Neil-Dunne—developed process protocols for using LiDAR to analyze the urban tree canopy. The team completed canopy assessments for more than 50 cities and towns encompassing more than 300 communities, mostly in the Mid-Atlantic and Northeastern States. Canopy estimates made using LiDAR are considerably more accurate than those using reflected light. In Philadelphia, for example, previous canopy estimates ignored small trees and put the total tree canopy at 10 percent of the city's total land area. The more advanced LiDAR techniques accurately detected smaller patches of canopy and revealed twice the amount (6,832 hectares) of existing tree canopy.

Forest Land Estimates Improved by Novel Automated Mapping Technique Using Winter Satellite Imagery

Incorporating winter imagery in the mapping approach helps reduce the abundant false positives for forest and forest disturbance that frequently occur during the growing season, especially where forest is intermixed with wetland and agricultural landscapes

FIA program plot data provide invaluable information about the distribution and health of our Nation's forests to scientists and the public alike. Forest Service scientists, in cooperation with the University of Maryland Department of Geography, found that winter satellite imagery with the vegetation change tracker (VCT) could generate more reliable estimates of forest lands in the western Great Lakes area.



▲ Comparison of vegetation change tracker output products without (left) and with (right) snow-covered winter satellite imagery. *Kirk Stueve, Forest Service*

Profile in Science—Sybill Amelon

"Bat woman" works to save an important, misunderstood species

Sybill Amelon is a research wildlife biologist stationed in Columbia, MO, at a Forest Service laboratory associated with the University of Missouri. She has had a long career with the Forest Service and currently serves as the Forest Service Research and Development liaison to the interagency task force developed to respond to white-nose syndrome (WNS) in hibernating cave bats.

Amelon happily describes herself as a "bat woman." She talks about her research subjects with concern and enthusiasm and handles the sick and injured individuals she cares for as tenderly as beloved pets.

"They are so high-tech and sophisticated, and people have such horribly maligned thoughts about them," Amelon said. "They're so beneficial to so many ecosystems. ... They pollinate plants, and they eat insects. They orient by radar. They are really, really cool."

Bats' nocturnal habits require Amelon and her team from the Forest Service Northern Research Station in Columbia to conduct their summer fieldwork in the hot, humid months; they essentially work the swing and graveyard shifts. "You're on a totally different schedule than most of the world," Amelon said.

When the field season is over, Amelon returns to normal working hours and her subjects huddle in caves for winter hibernation. The females, having recently mated, store sperm inside their bodies until fertilization happens in the spring. Once pregnant, they seek out the peeling bark of a dead or dying tree and squeeze under it to birth their pups and nurture them until they can fly on their own.

Amelon is one of few licensed bat rehabilitators in Missouri and uses bats that cannot be returned to the wild in educational programs. She is working in conjunction with Bat Conservation International in Austin, TX, and Bat World Sanctuary in Mineral Wells, TX, to educate the public on the importance of bats and the current threats to their existence.

Bats are a vital component of many ecosystems, eating billions of insects, including mosquitoes and crop pests.

▲ Sybill Amelon, Research Wildlife Biologist. *Forest Service*

One bat can consume more than 500 mosquitoes in an hour; 100 bats can eat 1.1 kilograms of insects a night. Unfortunately, many bat species could be facing extinction due to the rapid spread of a cold-loving fungus, Geomyces destructans, previously unknown to science. This newly emerging disease is called white-nose syndrome because it was first noticed as white "fuzz" on the noses and faces of hibernating bats. Since its discovery, the disease has spread rapidly in caves and mines up and down the Appalachian Mountains and in 14 States and two Canadian provinces. Colonies of hibernating bats have been reduced by 81 to 97 percent, and more than 1 million bats have already died.

Amelon and her fellow "bat scientists" are working to understand and counter the effects of the fungus by developing improved techniques to detect early-stage infections and track the spread of the fungus in the environment; investigating the potential for biological or chemical control of the WNS fungus; and evaluating the effect of current bat death rates on the Indiana bat, a federally listed endangered species.

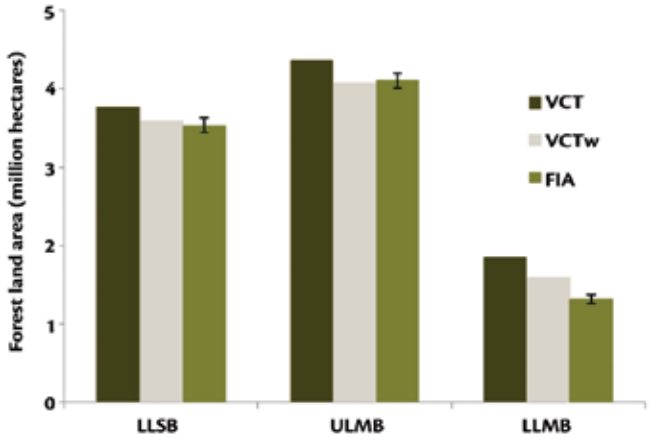
In addition to suffering from the deadly fungus, migratory bats are suffering high mortality from wind turbines across the continent. By some estimates, 33,000 to 111,000 bats will be killed annually by wind turbines in the Mid-Atlantic Highlands alone by 2020, if projected wind turbine development projects are constructed.

"This important species is fighting a war on two fronts," Amelon said. "The work we are doing today may be crucial for its long-term survival."

These VCT data were consistent with those from FIA plots. The VCT is an automated forest-mapping algorithm that exploits the Landsat archive to produce comprehensive maps of forest changes and is well-suited to filling in data gaps between FIA plots. Using winter imagery exploited sharp seasonal contrasts of forested and nonforested areas and enabled the removal of most false positives, providing an efficient and reliable option for filling in gaps between FIA plots. False positives for forest and forest disturbance are a serious problem for the gaps in many FIA data grids, especially

in intermixed forest and wetland and agricultural landscapes.

Lead: Northern Research Station



▲ Comparison of forest land estimates in the western Great Lakes from FIA plots and vegetation change tracker without (VCT) and with (VCTw) snow-covered winter satellite imagery. LLSB, lower Lake Superior basin; ULMB, upper Lake Michigan basin; LLMB, lower Lake Michigan basin. *Mark Nelson, Forest Service*

Five-Year Forest Inventory and Analysis Report Summarizes Forest Conditions in Washington

Information establishes a baseline against which to compare future conditions and to identify trends

Forest Service scientists, in cooperation with the Washington Department of Natural Resources, summarized and interpreted basic information about public and private forest land in Washington State. Topics included land use change, ownership, timber volume, biomass and carbon stocks, biodiversity, insects and diseases, invasive plants, air pollution, and more. The report, based on data from 2002 through 2006, establishes a baseline against which to compare future conditions and to identify trends. This information is useful to State and Federal agencies and private firms. The authors identified several key findings in the report. They found that Washington's forest land is presently a net sink for carbon, whereas most timber production is coming from private lands. Nonnative invasive plant species already are well established in Washington's forests, covering 4 percent of all forest land, on average. They also found lichen communities indicative of nitrogen pollution in forests west of the Cascade Range, particularly in the Puget Trough ecoregion, which runs the length of the State along the Interstate 5 corridor.

Lead: Pacific Northwest Research Station

Study Highlights Knowledge Gaps Regarding Wetlands Conservation Practices in the Southeast

Scientists established a critical need to incorporate wetland types as a component of assessing ecosystem services

Led by the USDA Natural Resources Conservation Service, the Conservation Effects Assessment Project (CEAP) conducts nationwide assessments to quantify the effectiveness of conservation practices applied in agricultural landscapes. The CEAP–Wetlands group specifically evaluates practices that protect or restore wetland ecosystem services, such as water quality improvement, floodwater storage, and wildlife habitat. As part of a CEAP effort, multiple research partners produced seven regional reviews and a cross-region analysis that were published as a special issue of the journal *Ecological Applications*.

Forest Service scientist Diane De Steven and her fellow scientist, Richard Lowrance from the USDA Agricultural Research Service, led the Mid-Atlantic/Southeastern Coastal Plain review, which examined current evidence for practice effectiveness and highlighted research needs for the region. The collaborators found that the nature and outcomes of wetland restoration practices on most southeastern program lands were undocumented, and they identified a critical need to incorporate wetland types as a component of assessing ecosystem services. The scientists' review resulted in new CEAP funding to the Forest Service's Southern Research Station for a research study that will analyze wetland restoration practices across several Southern States. The findings will improve conservation planning, project outcomes, and monitoring of wetlands-related practices and programs for working lands in the South and elsewhere.

Lead: Southern Research Station

Forest Inventory and Analysis Begins Work on Hawaiian Islands

Policymakers and natural resource managers need up-to-date, consistent, and credible information on the status and trends of forests in Hawaii and the Pacific Islands to guide decisions at State, national, and international levels.

FIA work began on the Hawaiian Islands with installation of potential study plots on the islands of Hawaii, Lanai, and Oahu. The Pacific Northwest Research Station delivers the FIA program in Hawaii and partners with the Hawaii Division of Forestry and Wildlife, the Institute of Pacific Islands Forestry, and numerous other agencies, including State

Science Solution

Forest Service Teaches Tribes How To Cultivate Culturally Significant Plants

Tribes are eager to learn new strategies to restore their native lands

The Forest Service's Reforestation, Nurseries, and Genetic Resources Team provides an important forum for Native American tribes to network regarding native plant production and restoration. As a result, team leaders have worked with nearly 80 tribes and one-on-one with more than 500 tribal members across the United States and Canada, teaching them how best to propagate culturally significant plants for their own use.

Scientists at the agency's Rocky Mountain Research Station are currently working on writing nearly 300 native plant propagation protocols the tribes requested. Native peoples have now sought out this expertise nationally and internationally, as they are increasingly taking part in the restoration of their lands with culturally significant native plants. Several awards have recognized the quality and effectiveness of the team's efforts, including the Earle R. Wilcox Award from the Intertribal Timber Council.

In 2011, Forest Service scientists helped conduct a native plant nursery planning workshop in Wisconsin. Attendees came from the College of the Menominee, Menominee Tribal Enterprises, the Oneida Tribe, the Keweenaw Bay Indian Community, the Sault Tribe of Chippewa Indians, and the Redlake Band of Chippewa Indians. Several of these tribes are in the beginning stages of native plant nursery production and are eager to learn new strategies for planning, implementing and conducting their own programs. The two-day workshop included lectures and tours on nursery planning, implementing agroforestry programs, and greenhouse operations. The event was well-received among tribal participants, with open discussions promoting the use of native plant nurseries for tribal restoration projects, reforestation, education, cultural preservation, and science.

▲ Tribe members attending a native plant nursery planning workshop. *Forest Service*

"[The scientists] fill an important role by helping the Forest Service direct its expertise and resources dealing with forestry and native plants to areas where we need help," said Priscilla Pavatea of the Hopi Office of Range Management in Kykotsmovi, AZ. "We trust them to provide us quality information. Their help is not directed only to Hopi. Many tribes are participating in the Intertribal Nursery Council they organize and taking home knowledge on how to produce native plants for reforestation, cultural, medicinal, and spiritual needs."

▲ A field technician installs a potential study plot on the island of Oahu. *Natalie Tangalin, Forest Service*

governments and foresters throughout the Pacific, to implement this inventory. In 2010, the Pacific Northwest Research Station hired a Hawaiian field crew, who installed most of the potential study plots on the islands of Lanai and Oahu and began work on the island of Hawaii. The station also strengthened its partnerships with the Hawaii Division of Forestry and Wildlife and the Institute of Pacific Islands Forestry and established itself as an important future resource to understanding the status and trends of Hawaii's forest resources.

Lead: Pacific Northwest Research Station

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