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USDA Forest Service RESEARCH & DEVELOPMENT 2012–13 Highlights

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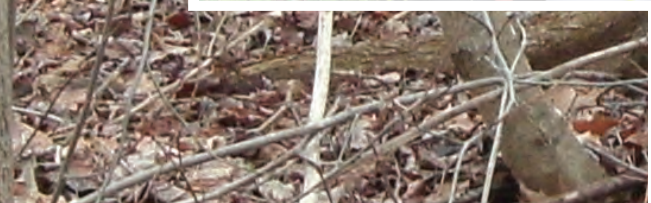


Welcome From the Deputy Chief

Research in Support of Restoration

The conservation agenda for the 21st century can be summed up in one word—restoration. The research arm of the U.S. Department of Agriculture (USDA), Forest Service is dedicated to producing and delivering the science necessary to help all land managers in the United States—public, private, or nonprofit—realize this vision.

"Restoration" does not mean restoring ecosystems and landscapes to some perceived ideal from historical records; rather, it means working to restore all U.S. forests and grasslands to healthy, biologically rich, and productive environments that offer a sustainable supply of ecosystem values and traditional and nontraditional forest products. From clean air and water, to wildlife habitat, to re-engineered wood for "green" building projects, to niche products such as wild onions known as "ramps," to beautiful places that people visit for recreation or relaxation, Forest Service Research and Development (R&D) must bring its science to bear on all aspects of the agency's restoration work, whether on national forests; State, county, or tribal lands; or urban centers. Healthy, productive forests and grasslands will be resilient to wildfire, protect watersheds so they can continue to clean and purify a healthy flow of water for humans and wildlife, and bolster rural economies with green jobs and green forest products. Restoration means restoring the ecological functions associated with healthy forest ecosystems, which remain resilient under drought conditions and assault by fire, insects, and disease.

Given current ecological conditions, restoration on a meaningful scale depends on land owners and managers understanding that "we are all in this together" and responding collectively. Restoration of such a magnitude will require many partnerships to sustain the entire matrix of Federal, State, tribal, county, municipal, and private forests. Our research will give land managers and owners the knowledge and tools they need to improve ecosystem and watershed health, generate rural prosperity, and meet our shared vision of healthy, resilient landscapes.

An "all-lands" approach to restoration means the demand for R&D research results will keep growing, regardless of economic conditions. Meeting this increased demand requires additional resources. Partnerships will be an important source for funding and leveraging Federal capacity.

The research highlights in this report give a good indication of the depth, breadth, and quality of Forest Service R&D conducted in support of all-lands restoration. Organized by areas of national importance called "Strategic Program Areas," or SPAs, this report showcases our most recent achievements in wildland fire and fuels; water, air, and soil; wildlife and fish; invasive species; outdoor recreation; and resource management and use. It also includes priority research areas that cut across many or all of the scientific disciplines in our research portfolio, such as forest disturbance, climate change, and biomass and bioenergy. A special feature of this issue is several "Conversations With Conservation Leaders." These conversations allow readers the luxury of spending time with several knowledgeable and articulate scientists and leaders who have dedicated their working lives to aspects of conservation. I am proud to call them colleagues and trust you will find their shared experiences and philosophies regarding conservation as engaging as I do.

An increasingly important role for Forest Service scientists is to synthesize large bodies of research into usable chunks of knowledge to help land managers succeed at their work. As author John Naisbitt once said of the modern world, "We are drowning in information but starved for knowledge." Forest Service R&D is uniquely qualified to extract knowledge from the yearly avalanche of fresh research results on environmental topics and deliver it to clients in easily accessible forms and places. Recent examples include:

The **cell phone application for invasive plants** developed at the Forest Service's Southern Research Station. Any hiker in possession of a cell phone can now identify an invasive species and record its location.

The **Wildland Fire Decision Support System** (WFDSS) was named winner of the 2013 Award for Excellence in Technology Transfer. This prestigious award recognizes the outstanding work of the Rocky Mountain Research Station's Wildland Fire Management Research Development and Application unit at transferring Federal research to land managers and the public. WFDSS assists them with the process of making strategic and tactical decisions during wildfire incidents. It streamlines the analysis and reporting process by integrating various applications into a single Web-based application.

ForWarn is a forest-change recognition and tracking system that uses data from the National Aeronautics and Space Administration satellites to develop near real-time maps for the continental United States. The Forest Service's Eastern Forest and Western Wildland Environmental Threat Assessment Center received the Federal Laboratory Consortium for Technology Transfer's 2013 Interagency Partnership Award for this system. This system helps forest resource managers rapidly detect, identify, and respond to known and unexpected disturbances in forests. *ForWarn* can be accessed from any Internet browser and is available at no cost to both private and public sectors.

A great long-running example of science delivery by Forest Service R&D is the recently released **2010 Resources Planning Act (RPA) Assessment**. The report is the fifth in a series that began in the 1970s in response to a congressional mandate to report every 10 years—with an interim report in between—on the status, trends, and future conditions of the Nation's forests and rangelands across all ownerships. This most recent assessment found that land development will continue to threaten the integrity of natural ecosystems as population growth drives expansion of urban areas. The increased population will also increase the competition for goods and services from natural landscapes. Climate change will alter natural ecosystems and affect their ability to provide goods and services. Since both human and climate effects will vary geographically, flexible management strategies will be needed to respond to local and regional management issues.

Welcome from the Deputy Chief

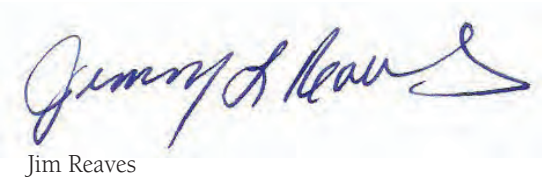
A year ago, the Forest Service R&D Agroforestry Program was elevated to the national level. As part of a new interagency agroforestry team, the program initiated work with land-grant university partners in 2012 to help minority landowners in the Southeast consider agroforestry as an option for their farms, ranches, and woodlands. Also worth noting is the program's increasing cooperation with Canada's Agroforestry Development Centre. A Memorandum of Understanding between the USDA and Canada's Agriculture Department has set the foundation to share the latest information about ways to restore and innovatively design windbreaks in the Great Plains, the workhorse agroforestry practice in this region dating back to the Dust Bowl.

Agroforestry isn't the only Forest Service R&D program that is working beyond U.S. boundaries. USDA Secretary Tom Vilsack's all-lands approach of restoration means considering environmental practices in other countries, especially neighboring countries, just as they must consider our practices. Invasive species—such as cheatgrass in the West and the kudzu vine in the South—are obvious examples of how environments don't stop at a country's boundaries; by the way, Forest Service researchers have worked on both of those problems. I consider it a mark of honor that so many of our scientists are invited to present talks and seminars and give training in other countries. And, these days, the foreign countries or organizations generally pay for the travel expenses.

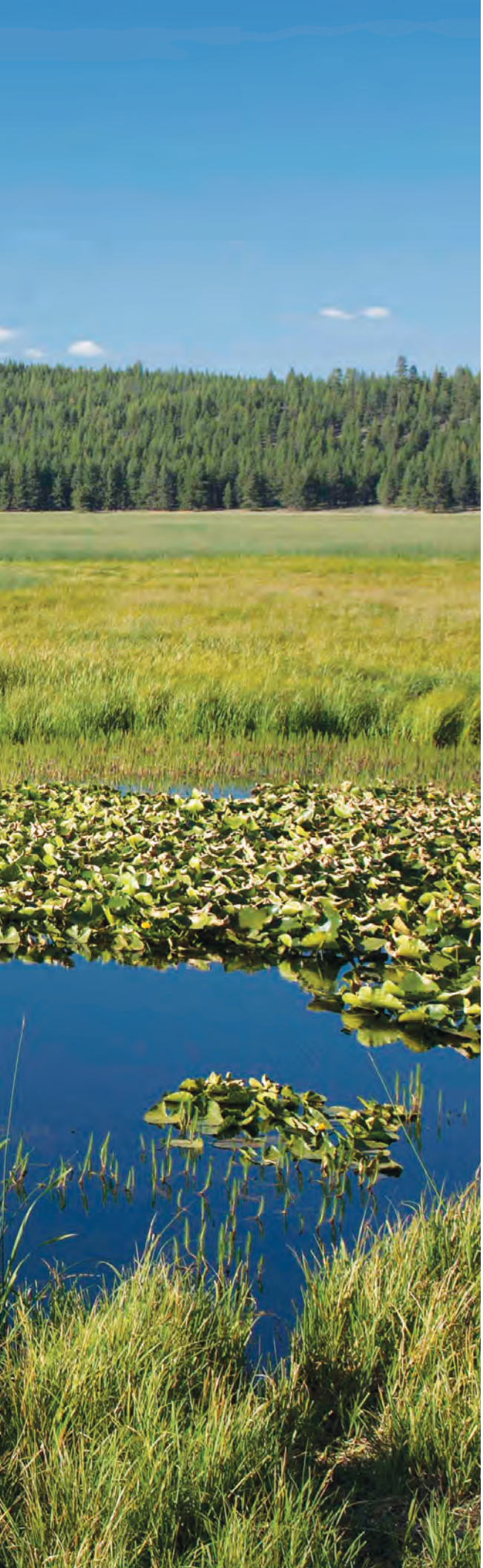
In May 2012, I attended an IUFRO (International Unions of Forest Research Organizations) conference in Sarajevo, Bosnia, to give a talk titled "Building a Natural Resources Program Through Collaboration." I experienced firsthand how eager scientists from other countries were to hear about our research and share their knowledge with us. The trip was one of the high points of my year, especially because I was able to witness firsthand the prestige with which scientists from other countries hold Forest Service researchers.

As the world's premiere science organization in natural resources conservation, we are expected to look into the future and forecast issues with the potential to adversely impact the productivity of our Nation's forests and rangelands. Just as we provided the foundational research that propelled Forest Service R&D into a leadership role in climate change 30 years ago, we are once again being asked to serve as the agency's eyes into the future and anticipate the conservation issues of this century. I'm happy to report that we are well positioned to meet this challenge thanks to our world-class cadre of scientists, skilled support staffs, and strong partners. One of my priorities over the last few years has been building a stronger, more diverse, and more inclusive workforce. We are starting to reap the dividends of that effort in terms of camaraderie, teamwork, and productivity. Our team has never been stronger or more relevant to the agency's mission. In the words of Raphael Zon, an early pioneer of forest research who retired from the Forest Service after 43 years of service, "The greatest contribution of Forest Research is the spirit it has brought into the handling of national resources … It is forest research which has kept the sacred flame burning and has helped to raise forestry to the level of the leading scientific professions."

Enjoy reading about our research highlights. They are by no means comprehensive but they do offer a real indication that we are striving to live up to our motto of *Science Serving Society*.



Jim Reaves
Deputy Chief, Forest Service R&D



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Introduction

The Research and Development (R&D) deputy area 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, more than 500 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 by maintaining programs in all 50 States, U.S. territories, and U.S. commonwealths. The work has a steady focus on informing policy and land-management decisions, whether it addresses forest restoration, 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 scientific information and technology produced through basic and applied science programs are available to the public to use for its benefit.

Forest Service R&D organizes research under seven Strategic Program Areas (SPAs), which support an integrated approach to studying 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, agency Deputy Areas, and external partners.

Invasive Species

The Invasive Species Strategic Program Area 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.

Photo credit: Connecticut Agricultural Experiment Station

Predicting the Path of the Amber-Marked Birch Leaf Miner

Scientists model future infestation of an invasive insect in Anchorage, AK

The amber-marked birch leaf miner is a leaf-eating insect that has infested trees in Anchorage since 1996. These infestations have received much attention from homeowners and extension agents. Although researchers have been studying the infestations and thousands of dollars have been spent trying to reduce the insects' effects, effective management techniques to mitigate the problem across landscape scales remain elusive. Amber-marked birch leaf miner infestations create distinct, patchy landscape-scale patterns involving multiple trees synchronized across multiple urban neighborhoods. These patches appear to migrate across neighborhoods from year to year. Areas with a relatively high intensity of infestation one year will experience a relatively low intensity the next year. This study generated spatial distribution models of the leaf miner in the Anchorage area and compared and contrasted spatial distributions across years. The modeling methods developed in this study enable the numerical analysis of invasive insect populations across large spatial and long temporal scales. The model also projects future insect infestation levels and distributions. These projections have been shared with the municipality of Anchorage and the University of Alaska, Fairbanks Cooperative Extension Service.

Lead: Pacific Northwest Research Station

Beetle Pheromones Save Endangered Pines From Bark Beetles

High-elevation pines protected by turning beetles' own pheromones against them

Forest Service scientists along with research partners from the University of California at Berkeley and the University of Alberta developed pheromone-releasing flakes that prevent bark beetle attacks and protect whitebark and limber pines. The flakes release a behavioral chemical that convinces beetles that the treated trees are not good host trees in which to reproduce. The scientists applied the pheromone releasing flakes in two ways: in aerial applications over large stands of trees and in sticker applications to individual tree trunks. They compared subsequent bark beetle attack in treated stands with that in untreated stands. Protection ranged from 50 to 80 percent, even for trees baited with the beetle's aggregation pheromone. The flakes can be dispersed into remote, high-elevation stands even when snow is on the ground, when beetle attack commonly occurs. The flakes provide a nontoxic alternative to insecticides that protects high-elevation pines from bark beetles. The application of the flakes benefits public land managers attempting to protect and preserve fragile, high-elevation pine ecosystems that are habitat for grizzly bears and Clark's nutcracker. The most common uses for the flakes are at campgrounds, administrative sites, ski areas, and rust-resistant stands used for genetic conservation. Scientists conducted the research in Colorado, Montana, Wyoming, and Washington.

Researcher applying pheromone-releasing flakes to a whitebark pine bole. *Forest Service*

Lead: Pacific Southwest Research Station

Biocontrol of Strawberry Guava

First field release of biocontrol agent for managing invasive strawberry guava

The Forest Service and the Hawaii Department of Agriculture conducted the first field release of a biocontrol agent for strawberry guava in Hawaii beginning in December 2011. Releases to build populations of the biocontrol agent have continued at two Hawaiian island demonstration sites monitored by a Forest Service research entomologist. The highly host-specific leaf-galling scale insect *Tectococcus ovatus* was imported from its Brazilian native range and studied during the past decade to determine its suitability for introduction to manage strawberry guava, a widespread and devastating invader of native rainforests. Unusually cool temperatures have slowed the initial establishment of galls in the field, but the onset of summer has rapidly increased gall development. Potentially reproductive galls appeared in July 2012, providing the first indication of a self-sustaining population. These establishment sites will serve to demonstrate the specificity and effect of the agent and will be used to initiate further releases in native forests, where biocontrol is intended to slow the spread of strawberry guava and complement other approaches for long-term management of the species.

Red fruit of strawberry guava. *Forest Service*

Lead: Pacific Southwest Research Station

Forest Service Research Used in New Invasive Plant Phone Application

iPhone application helps people identify harmful, nonnative plants and provides control recommendations

Across the South, invasive plants cause incalculable damages to forests and, in many cases, completely destroy natural habitats. Forest Service research and funding led to the development of a free software application that helps people identify and control destructive invasive plants in southern forests and grasslands. The *Invasive Plants in Southern Forests: Identification and Management* application is currently compatible with Apple products—iPad, iPhone, and iPod Touch—and available through iTunes. The software provides photos and information that allow users to identify the 56 nonnative plants and plant groups currently invading the forests of the 13 Southern States, and it provides control recommendations. A Forest Service grant funded the development of the application by the University of Georgia Center for Invasive Species and Ecosystem Health in collaboration with Forest Service Emeritus Scientist Jim Miller. The software is based on the invasive plant guides developed by the Southern Research Station with Miller as the lead author and photographer. Like the guides, the application divides invasive plants into trees, shrubs, vines, grasses, ferns, and forbs and provides identification keys, photos, and management recommendations. Users also get simple, on-the-spot options for treating invasive plants. Since the guide's release, more than 200,000 copies of the printed version have been distributed. The plant application will inform many more people about the effect of invasive plants and provide a basis for people to get involved in eradication efforts. Future versions of the application will include the ability to directly report new sightings of select invasive plant species into the Georgia Center's Early Detection and Distribution Mapping System, which provides a quick way to submit photos and report new sightings of invasive plants, on the spot, throughout the United States.

Free downloadable software application helps people identify Invasive plants of the South. *Forest Service*

Lead: Southern Research Station

Forest Community Dynamics After Widespread Die-Off From an Invasive Insect

Understanding how microclimate and forest community dynamics respond to eastern hemlock die-off

Forested watersheds are an especially important regulator of the Nation's water supply because managed and unmanaged forests provide the cleanest and most stable water supplies for drinking water, aquatic habitat, and groundwater recharge compared with all other land uses. Understanding how disturbances, such as the widespread die-off of a foundation tree species like eastern hemlock, restructure the forest community is critical to understanding the controls and partitioning of water in these headwater catchments. Understanding changes in community composition caused by invasive species is critical for predicting probable effects on ecosystem function.

A Forest Service study quantified changes in microclimate, community composition, and growth in southern Appalachian eastern hemlock forests during 7 years of infestation by the invasive hemlock woolly adelgid. A separate, simultaneous treatment mimicked infestation by girdling hemlock trees. Mortality was rapid, with 50-percent hemlock tree mortality occurring after 6 years of invasion, and 2 years after girdling. Because the leaf area lost by infested hemlock was similar to that of girdled trees during the study, the changes in light, growth, and soil moisture were identical in the infested and girdled stands. Increased growth of co-occurring canopy trees was limited to the first few years, while increased growth of the evergreen shrub, rhododendron, continued over time. After 7 years, it had a 2.6-fold higher growth rate than expected, responding to increased light during leaf-off periods of the deciduous species. Increased growth and dominance of rhododendron may be a major determinant of future responses in southern Appalachian ecosystems; however, the results suggest a mix of maple, birch, beech, and oak canopy genera will replace hemlock where establishment is not limited by rhododendron.

Hemlock wooly adelgid covers the leaves of a hemlock tree. *Connecticut Agricultural Experiment Station*

Lead: Southern Research Station

Invasive Chinese Tallow Reduces Hatching of Frog Eggs

Decomposing leaf litter reduces hatching of southern leopard frog eggs by lowering the pH and concentration of dissolved oxygen in the water

Chinese tallow is an aggressive invasive tree species that can be abundant in parts of its nonnative range. This tree species has the capability of producing monocultures by outcompeting native trees, which can be in or near wetlands that are used by breeding amphibians. Existing research suggests that leaf litter from invasive Chinese tallow reduces survival in larval anurans including the southern leopard frog. The purpose of this study was to determine the effects of Chinese tallow leaf litter on anuran eggs. The scientists exposed eggs of the southern leopard frog, at various stages of development, to different concentrations of Chinese tallow leaf litter to determine survival.

Eggs in the earliest stages of development that were exposed to tallow leaf litter died, regardless of concentration; however, some more developed eggs exposed to tallow leaf litter did hatch. The scientists determined that the greater the concentration of tallow leaf litter, the lower the dissolved oxygen and pH levels were observed. The results suggest that changes in these water-quality parameters are the cause of the observed mortality of anuran eggs in these experiments. Eggs exposed to water containing tallow leaf litter, with dissolved oxygen levels of less than 1.59 miligrams per liter and a pH level less than 5.29, did not survive to hatching.

A chorus frog threatened by invasive Chinese Tallow. *Forest Service*

Lead: Southern Research Station

Unwanted Side Effects of Roads Are Invasive Species

Monitoring invasive plants is an important component of forest restoration

Burning and thinning treatments are increasingly being used in western forests to manage the infestation of insects and disease as well as to reduce wildfire hazards. Unfortunately, these treatments can trigger the invasion and spread of invasive plants, which can thwart restoration efforts. Land managers need to be aware of this unwanted potential side effect and be armed with the knowledge to best monitor and treat weeds after restoration. The effects of burning and thinning treatments on the introduction and spread of invasive plants are not well understood, however. A recently published, long-term Forest Service study conducted at the Tenderfoot Experimental Forest in Montana helps shed some light on the spread of invasive plants. Conducted in a lodgepole pine forest in central Montana, the study involved researchers monitoring noxious weeds after thinning and burning treatments and surveying treatment units and along roads. Researchers found five species that were listed as noxious weeds in Montana: spotted knapweed, oxeye daisy, Canada thistle, common tansy, and houndstongue. With the exception of Canada thistle, noxious weeds were confined to roadsides and did not colonize silvicultural treatment areas. This example highlights the importance of roads for weed distribution and spread, and it suggests that the effects of roadways should be considered when evaluating the potential for invasion of exotic plants after restoration treatments. In the Tenderfoot Experimental Forest, weed control along adjacent roads and in heavily disturbed areas, such as slash piles, may be a cost-effective and efficient tactic to limit exotic plant invasion. Although many questions remain, and more research is needed on this topic, it is clear that monitoring invasive plants within treated areas and along roads should be a permanent component of forest restoration.

Noxious weeds were monitored following thinning and burning treatments in a lodgepole pine forest. *Forest Service*

Lead: Rocky Mountain Research Station

A Proactive Strategy To Control Invasive Species in Mountaintop Ecosystems

High-elevation pine forests, under the threat of multiple stressors, serve as an excellent flagship to lead the shift away from crisis management and toward proactive management for ecosystem resilience

People value high-elevation white pine forests because of the forests' aesthetics and longevity. These pines often define the very altitudinal limits of tree growth and help capture snow and control its melt at the headwaters of Northwestern American watersheds. The pines' large seeds also serve as food for many animals that play important roles in wildlife food chains. These forests and the headwater ecosystems the animals occupy are threatened, however, by the non-native lethal disease white pine blister rust. Many ecosystems in the West are already impacted. The southern Rocky Mountains are at the leading edge of the infection front, leaving the landscape susceptible to invasion, and the continued spread of the pathogen over time is inevitable. Without intervention, high frequencies of pine mortality will threaten the sustainability of the white pine species. Forest Service scientists and their partners developed a proactive strategy framework to sustain healthy high-elevation pine populations and mitigate the impact of white pine blister rust. The strategy was introduced in 2004 and further developed in 2007 and 2011. Land managers began implementing the framework in 2008. High-elevation pine forests, under the threat of multiple stressors, serve as an excellent flagship to shift conservation focus away from crisis management and toward proactive management that provides for ecosystem resilience.

Healthy Rocky Mountain bristlecone pine stand in Colorado threatened by white pine blister rust and mountain pine beetle. *Forest Service*

Lead: Rocky Mountain Research Station

Why Do the Exotics Beat the Natives: Where Is the Home-Team Advantage?

New research sets forth a framework for understanding why exotic plants invade and how to fight the invasions

According to a study published in the journal *Ecological Economics*, exotic invasive species cause approximately $120 billion in lost revenue, mitigation costs, and infrastructure and resource damage in the United States each year. Natural resource agencies and private land managers expend tremendous efforts to manage such invaders, but progress is slow because we often do not know why these invaders become so successful in their new ranges. The primary reason for this knowledge gap is the lack of comparative studies that examine how these species' behaviors differ between their native and invaded ranges. The current dogma surrounding invasive species is that they experience population release in the invaded range that results in larger populations and or larger plant sizes because they are released from constraining factors such as insect herbivores, pathogens, or other natural enemies when introduced, and that allows them to outcompete native plants. Remarkably, however, few studies have compared populations between the native and invaded ranges. In 2010, Forest Service scientists initiated an international collaboration to examine more than 35 species of exotic plants in their native range of Turkey and two invaded ranges, west-central Montana and central Argentina, to understand which species experience population release after invasion and why. Results suggest that, although some exotic plants do appear to become more abundant and larger in the invaded range, suggesting their release from some population limitations, others occur at comparable abundance or reduced abundance in the invaded range. This suggests that these species experience no net change in resistance or experience greater resistance where introduced. Findings show that identifying and managing for natural sources of biotic resistance can increase natural resistance to invasions at a relatively low cost, while more active management—such as biological, mechanical, or herbicide control—can be improved by directing the appropriate action at the right target species based on understandings of why it is released. This research sets forth a framework for understanding why exotic plants invade and how best to mitigate the undesirable effects of invasions.

Experimental disturbance that kills native plants helps invasion by tall tumblemustard, cheatgrass, lamb's quarters, prickly lettuce, Canada thistle, bull thistle, sweetclover, bulbous bluegrass, and herb Sophia. *Forest Service*

Lead: Rocky Mountain Research Station

Strong Demand for New Tool for Detecting Asian Longhorn Beetle

Beetle traps are now being used in 14 States and 3 countries

After 3 years of testing at the Worcester, MA, Asian longhorned beetle (ALB) infestation site, the best trap and lure combination tool to date is now being used in 14 States and 3 other countries to either help delimit known infestations or spot new ones near high-risk areas. In addition, the U.S. Department of Agriculture, Animal and Plant Heath Inspection Service ALB eradication program is evaluating how best to incorporate this new tool into its efforts. Researchers at the Northern Research Station continue to refine the lures, but the current lure has proven useful enough to enable other groups to try it out this year. Successful trapping of ALB where infested trees were still suspected to exist and in areas that had not yet been surveyed in the Worcester quarantine zone is helping the program to pinpoint lingering populations and determine where to intensify surveys to find additional pockets of beetles. Nine arboreta in the Sentinel Plant Network (including the National Arboretum); groups in Italy, Switzerland, and the United Kingdom; and State or Federal agencies in 13 States are currently placing traps. In addition to the collaborators' time and resource inputs, funding for this work has come from the Forest Service Forest Health Protection program, the Horticultural Research Institute, and the Alpha Wood Foundation. In 2012, a workshop and Webinar trained people how to use the traps.

Researchers check an Asian longhorned beetle trap in Worcester, MA. *Forest Service*

Lead: Northern Research Station

Emerald Ash Borer Natural Enemies Becoming Established in the United States

Optimism increasing for long-term management of the emerald ash borer

The emerald ash borer, an invasive beetle that is killing ash trees in North America, is here to stay. As the beetle sweeps across the landscape, vast areas of dead ash are left in its wake in rural and urban environments alike. Optimism that biological control will become an effective tool in managing the beetle is increasing with research confirming that biological control agents are establishing at release sites in several States. Forest Service scientists are working closely with other researchers, land managers, and citizen scientists to expand the U.S. Department of Agriculture, Interagency Emerald Ash Borer Biological Control Program. Biological control of emerald ash borer involves the release of small, highly specialized wasps, or "parasitoids," that seek and destroy the beetle's eggs or larvae in ash trees. Since Forest Service and Animal and Plant Health Inspection Service scientists in Michigan released the first parasitoids in 2007, the Emerald Ash Borer Biological Control Program has expanded to 15 States through 2012. During this time, Forest Service scientists and Federal, State, and university collaborators have been working to develop nondestructive methods to determine parasitoid establishment in ash trees. This work is paying off, and parasitoid establishment is now confirmed at release sites in Illinois, Indiana, Maryland, Michigan, Ohio, and Pennsylvania. Forest Service scientists also began collecting data at field sites in Michigan to assess the long-term effects of emerald ash borer biological control on ash health and regeneration.

Oobius female deposits eggs inside an ash tree, which may infect emerald ash borer larvae. *Forest Service*

Lead: Northern Research Station

Scientists Determine the Chemistry Between Ash Trees and Emerald Ash Borer Beetle

What makes some ash species so susceptible to emerald ash borer and others less susceptible?

North American green ash is highly susceptible to emerald ash borer. Improved nutrient balance and efficiency of amino acid utilization in green ash, together with reduced induction of defense compounds, may contribute to the green ash preference by emerald ash borer. Understanding the differences in nutritional and defensive chemistry among ash species and their roles in emerald ash borer preference and performance will help to elucidate mechanisms of host preference and resistance and thus aid in resistant tree breeding programs. The invasive emerald ash borer was first discovered near Detroit, MI, in 2002. It has since spread to 16 States and 2 Canadian provinces and has killed an estimated 50 to 100 million ash trees, causing devastating economic and ecological effects. All Eastern North American ash species are susceptible to the beetle to some degree, including green, white, black, blue, and pumpkin ash, with green ash being highly preferred and susceptible. Asian ash species in the beetle's native range appear to have some level of resistance. A Forest Service scientist is working with colleagues to elucidate differences in nutritional and defense chemistry of different ash species and examine their roles in emerald ash borer's preference and performance. Understanding the mechanisms of host preference and resistance will be critical for ash breeding programs to develop resistant trees. Research suggested that moisture content and nutrients were important selective forces in feeding behavior of the beetle's larvae. Improved nutrient balance and increased efficiency of amino acid utilization in green ash may contribute to its preference by emerald ash borer. Elevated levels of volatile compounds induced by adult foliar feeding in green and white ash, and lower levels of induced defensive compounds in green ash may also partially explain the preference for green ash by emerald ash borer.

Emerald ash borer adult feeds on an ash leaf. *Forest Service*

Lead: Northern Research Station

Balanced Approach to Surveillance Reduces the Cost of Invasive Species Detection and Control

New planning tool helps organizations make decisions on where and how much money to spend on invasive pests detection programs

Nationwide, State and Federal agencies invest significant budgets to seek and eradicate newly established pest populations of high concern, particularly nonnative forest insects and diseases such as the emerald ash borer, hemlock woolly adelgid, and oak wilt. With limited budgets, it is imperative to conserve money while providing an adequate level of protection. Forest Service scientists developed a new planning tool that helps organizations prioritize where to look for newly established invasive species populations and how much of the budget to spend on surveillance while minimizing the damage caused by invasive species. Invasive species threaten ecosystem stability worldwide and inflict sizable economic damage, including expenditures for control and losses of market and nonmarket benefits. Enhanced efforts to detect and eradicate newly established species are critical to reducing their ecological and economic harms. Cost-effective detection programs must balance the intensity and cost of detection with the costs of eradicating newly detected populations. In addition, surveillance programs are usually applied in environments under continual invasion pressure where the number, size, and location of established populations are unknown before detection. Forest Service scientists and an international team of partners developed a new planning tool that accounts for these features of the decision and invasion environment. It helps design long-term surveillance programs for high-concern invasive species to minimize the total costs of preventing their long-term establishment and spread. The tool helped evaluate the surveillance program for gypsy moth in California. They found that allocating surveillance effort across counties, in proportion to surveillance cost and gypsy moth establishment rate, could save the State more than $200,000 annually in surveillance and eradication expenditures.

Gypsy moth trap used to detect new populations. *Forest Service*

Lead: Northern Research Station

Forest For Every Classroom Engages Students in Environmental Topics

Building a network for place-based environmental education in Wisconsin

Forest For Every Classroom is a year-long professional development program for K-12 (kindergarten through 12th grade) teachers that emphasizes place-based education and service learning as one of the most effective methods for connecting youth to nature. With LEAF (Wisconsin's K-12 Forestry Education program), Forest Service scientists and conservation educators brought together resources and expertise from six additional education partners and all three Forest Service mission areas. The Forest Service worked along with LEAF to complete the first year of Forest For Every Classroom training. This year-long, place-based model of professional development engages teachers in 11 days of training throughout the year and helps develop a network of educators, education providers, and natural resource professionals to cultivate a sustained change in teachers' approaches to education.

Eighteen educators, administrators, and community members participated in Wisconsin's first replication of Forest For Every Classroom program. *Forest Service*

Lead: Northern Research Station

FRAME Study Looks at Invasive Plants in Delaware

What are the causes and consequences of soil, plant, and animal changes in the valuable patches of forests that make up urban parks, riparian buffers, and undeveloped lots?

A collaborative study that was undertaken 45 years ago between the University of Delaware and the Forest Service outlined the benefits of local urban forests, essentially describing what we now call ecosystem services. In 2009, long-term data from these studies in northern Delaware were used to design the Forest Fragments in Managed Ecosystems (FRAME) study. The goal of FRAME research is to understand the causes and consequences of soil, plant, and animal changes in the valuable patches of forests that make up our parks, riparian buffers, and undeveloped lots. This research addresses a widely recognized problem—invasive nonnative plants—in terms of the overall ecology of urban forest fragments. Beginning in 2009, Forest Service scientists characterized 21 sites in northern Delaware ranging from 2.1 to 16.0 hectares in size, starting from soil analyses and working up through litter, understory plants, arthropods, reptiles, amphibians, and birds. A unique aspect to this research is that it is informed by work begun in the 1960s in some of the same patches by the Forest Service and the University of Delaware. The 1965 report was prescient in its recognition of urban forest benefits, ranging from mental health to clean air and water. Only 2 years into the project, scientists are finding profound changes in the density of nonnative plant species in the understory, their relationship to native songbird habitat use, and their connection to underlying soil conditions. The coastal mid-Atlantic region is a hotspot for these issues because of its long history of settlement, population density, value to migrating birds, and moderate climate.

Forest Service scientists and the Carolina wren. *Forest Service*

Lead: Northern Research Station

Impact of Invasive Insects and Fire on Forest Water Resources

Minor disturbances in forests that do not significantly alter biomass can reduce water use and increase ground water recharge to aquifers

Forest Service scientists quantified water use by forests that were defoliated by gypsy moth or burned by prescribed fire. Defoliation and prescribed fire initially had little effect on overall stand biomass but did reduce leaf area, which altered energy partitioning and reduced evapotranspiration. At the landscape scale, defoliation of about 20 percent of the forest increased ground water input by 7 percent. Forest Service scientists quantified energy exchange and evapotranspiration in three representative upland forest stands in the New Jersey pinelands that were either defoliated by gypsy moth or burned in prescribed fires. Defoliation and prescribed fire reduced leaf area, altered the partitioning of available energy, and reduced water vapor flux compared with undisturbed periods at the same location. For all years measured, leaf area accounted for 82 percent of the variability in daily evapotranspiration during the summer at an oak-dominated stand and for 80 percent of the variability at mixed and pine-dominated stands. When averaged across all stands and years, annual evapotranspiration was approximately one-half of incident precipitation (24 inches per year), similar to long-term averages reported in other studies in the New Jersey pinelands. Gypsy moth defoliation reduced evapotranspiration in the heavily defoliated oak stands by 9 inches per year, and by about 1.5 inches per year across all upland forests, resulting in a 7.3-percent increase in ground water recharge to the Kirkwood-Cohansey aquifer. This research indicates that nonstand replacing disturbances can have significant, but typically short-term effects on energy partitioning and evapotranspiration at the stand and landscape scales.

Lead: Northern Research Station

Inventory, Monitoring, and Analysis

The Inventory and Monitoring Strategic Program Area provides the resource data, analysis, and tools needed to identify current status and trends of forests; management options and effects; 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 monitoring 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.

Photo credit: Joel Gramling, The Citadel

Mapping Hardwood and Softwood Vegetation Types With New Technology

Study informs forest management activities and assesses woodpecker habitat

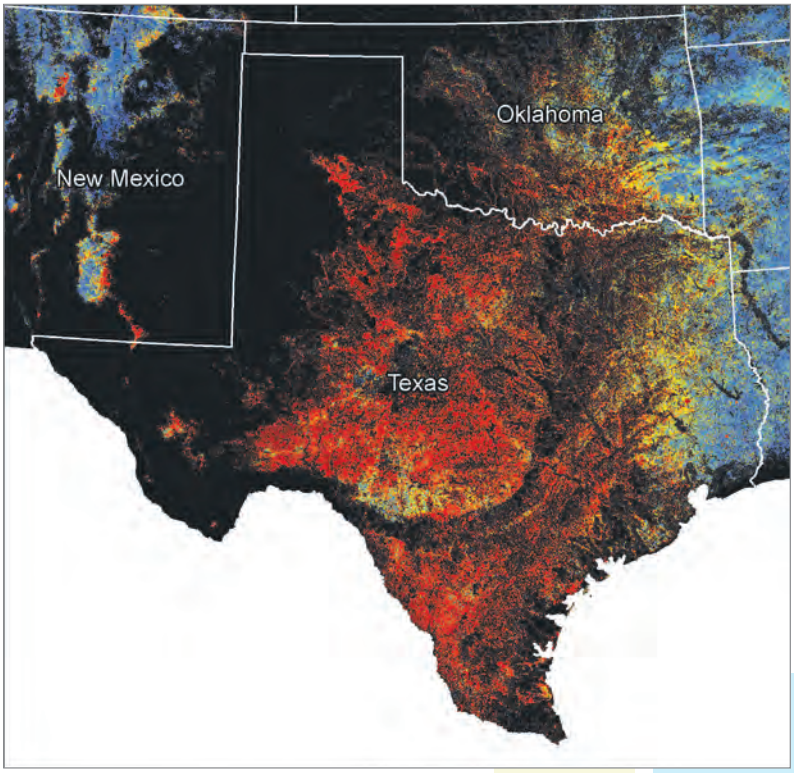
Managers at the U.S. Department of Energy's Savannah River Site in South Carolina are using the summarized geographic information system (GIS) data layers that were produced during this research to assess the availability of small-diameter hardwood material for bioenergy production and the suitability of the habitat for the endangered red-cockaded woodpecker. In this study, Forest Service scientists developed an innovative technique for characterizing species class by using a combination of Light Detection and Ranging, or LiDAR, technology and forest structure information. This approach was used to identify hardwood and softwood vegetation in a 19,800-acre study site. The presence or absence of hardwood species and their position in the forest canopy often dictate the application of management activities such as thinning or prescribed burning in southeastern forests. The characteristics of the understory and midstory layers are also key factors when assessing habitat for threatened and endangered species such as the red-cockaded woodpecker.

Lead: Pacific Northwest Research Station

ForWarn Tool Monitors Forests Coast-to-Coast

Web-based tool provides a weekly snapshot of U.S. forest conditions to aid forest managers

To help forest and natural resource managers rapidly detect, identify, and respond to unexpected changes in the Nation's forests, scientists with tScientists and collaborators with the Southern Research Station, the Forest Service Eastern Forest Environmental Threat Assessment Center and the Pacific Northwest Research Station Western Wildland Environmental Threat Assessment Center developed ForWarn, a monitoring and assessment tool that produces sets of national maps showing potential forest disturbances every 8 days. This tool posts the results to the Internet for scientists and natural resource managers to examine. ForWarn compares current forest vegetation greenness with the normal greenness that would be expected for healthy vegetation for a specific location and day of the year, and then identifies areas that appear less green than expected. This tool provides a strategic national overview of potential forest disturbances that can focus and direct ground and aircraft observation efforts and resources. ForWarn is the first national-scale system of its kind that was developed specifically for responding to forest disturbances. It has operated since January 2010 and has provided useful information about the location and extent of disturbances—including tornadoes, wildfires, and extreme drought. Eastern and Western Threat Center scientists released ForWarn in March 2012, followed by a series of online training sessions attended by nearly 60 early adopter State and Federal forest managers. ForWarn is the result of ongoing cooperation among Federal and university partners and can be accessed at http://www.forwarn.forestthreats.org.



ForWarn forest change image: blue indicates normal forest conditions compared to the previous year, and green to red indicates moderate to extreme vegetative change. *Forest Service*

Lead: Southern Research Station

Wetlands Assessment Project Documents Outcomes of Conservation on Working Lands

Assessment project offers managers a tool to improve project planning and assessment of wetland practices on working lands in the South and elsewhere

The Conservation Effects Assessment Project, or CEAP, is a national effort to quantify and report the environmental effectiveness of Farm Bill conservation programs. The findings support CEAP national assessment goals and can assist in improving project planning and delivery of wetland ecosystem services on southern working lands. Led by the USDA Natural Resources Conservation Service, CEAP supports research and assessments of documented outcomes from conservation practices applied to working lands through Farm Bill programs. The CEAP-Wetlands component evaluates practices that restore or enhance wetland ecosystem services—such as water-quality improvement, carbon storage, and wildlife habitat. To address information gaps identified previously by the CEAP, Forest Service scientist Diane De Steven led a collaborative CEAP study using hydrogeomorphic analysis of wetland types plus rapid field surveys to assess southeastern restoration projects that have been implemented under the Wetlands Reserve Program. Analysis of more than 100 projects spanning a 12-year period revealed that the program has encompassed diverse wetland types and prerestoration habitat conditions. Most projects demonstrated evidence of providing functional wetland habitat at local scales. Some restoration practices favored original hydrodynamic functions, while others resulted in trade-offs that reduced some wetland services to enhance others. One innovative program use addressed restoration of natural hydrology function on degraded timber-harvested floodplains, with landscape-scale benefits for floodwater storage, water quality, and forest habitat. This innovative approach has potential for wider application across the region. By identifying ecological trade-offs and causes of unsuccessful outcomes, hydrogeomorphic analysis offers managers a tool for improving project planning and assessment of wetland practices on working lands in the South and elsewhere.

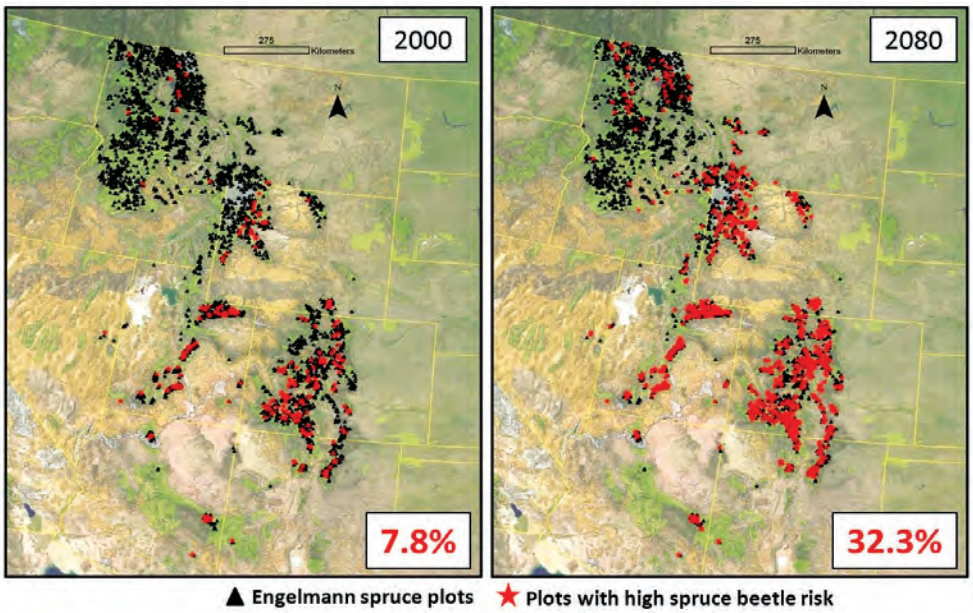
Former cropped wetland restored to a wetland by the Southeastern Wetland Reserve Program. *Joel Gramling, The Citadel*

Lead: Southern Research Station

Predicting Future Spruce Beetle Infestations

Scientists model the effects of increasing temperatures and forest stand conditions on the likelihood of spruce beetle infestation over time

In recent decades, bark beetle disturbances have been increasing in the Nation's forests. Although the increased rates of tree mortality have been attributed to the influence of warming temperatures on bark beetle life cycles, more research is needed to determine whether other potential factors exist and how those factors will change with the climate. As cause and consequences of spruce beetle infestation are important to the management of Engelmann spruce forests, Forest Service scientists modeled the effects of increased temperatures and changing forest stand conditions, such as density and species composition, on the likelihood of spruce beetle infestation over time. Global climate change scenario models were used to determine future temperatures, which were combined with forest stand conditions to make predictions of future beetle infestation. Results show that under all climate change scenarios, the percentage of spruce forest likely to be infested by spruce beetle increased, and the increase was most pronounced in the year 2080, when anywhere from 16.2 to 32.3 percent of forests in the Interior West could be infested. Temperature and stand conditions were equally important predictors. In particular, the amount of mature Engelmann spruce in a stand, in combination with increasing temperatures, greatly increases the likelihood of spruce beetle infestation. Although the amount of potential spruce beetle activity is predicted to increase, it is important to note that no model predicted the total loss of the spruce resource. These results corroborate previous studies that were conducted on the mountain pine beetle in Western North America. Findings are being incorporated into management guidelines for silviculturists who wish to mitigate spruce beetle infestation by modifying the density or composition of Engelmann spruce forests in the Interior West.



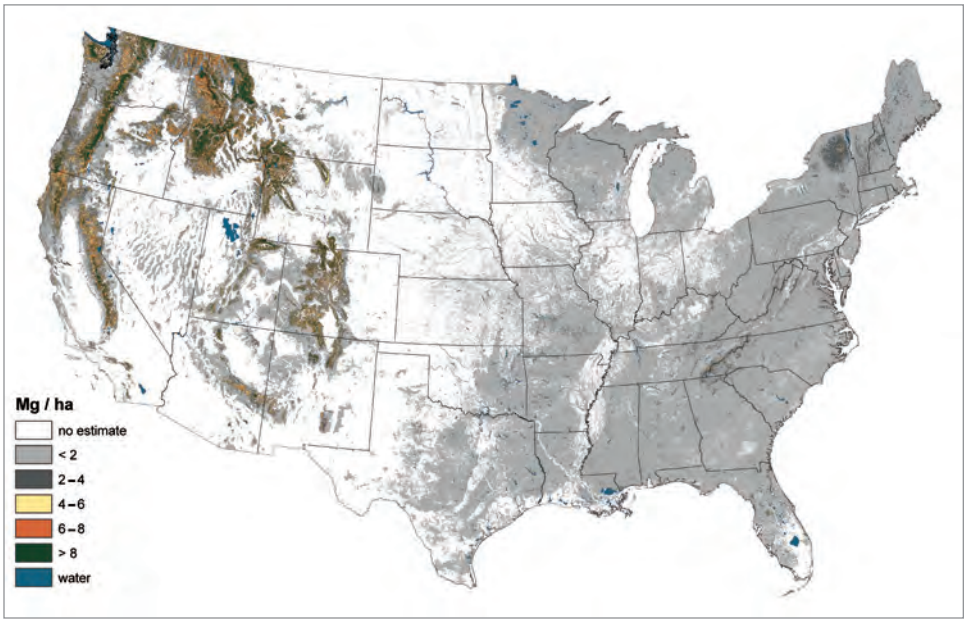
Current (2000) and future (2080) distribution of Forest Inventory and Analysis plots predicted to be at high risk of spruce beetle infestation based on the Canadian Global Climate Change model predictions of future temperatures. Numbers in lower right corner indicate percentage of plots with increased spruce beetle risk. *Forest Service*

Lead: Rocky Mountain Research Station

First Inventory of Standing Dead Trees Across the United States Developed

Study compares differences between previously modeled estimates and new empirical estimates

The Forest Service's Forest Inventory and Analysis Program now has a field inventory of standing dead trees across the United States replacing models that generalize regional averages by broad forest types. Instead of missing the effect of disturbances, such as droughts and insect outbreaks, disturbance effects on standing dead tree biomass and carbon estimates can now be measured in yearly time steps rather than in decades. In addition, beyond simply counting standing dead trees, emerging research on standing dead-tree wood-density reduction and structural deductions improves the accuracy of standing dead-tree carbon stock estimates. Emerging work to map these pools of biomass indicates that they are very prevalent in forests of the Western United States.



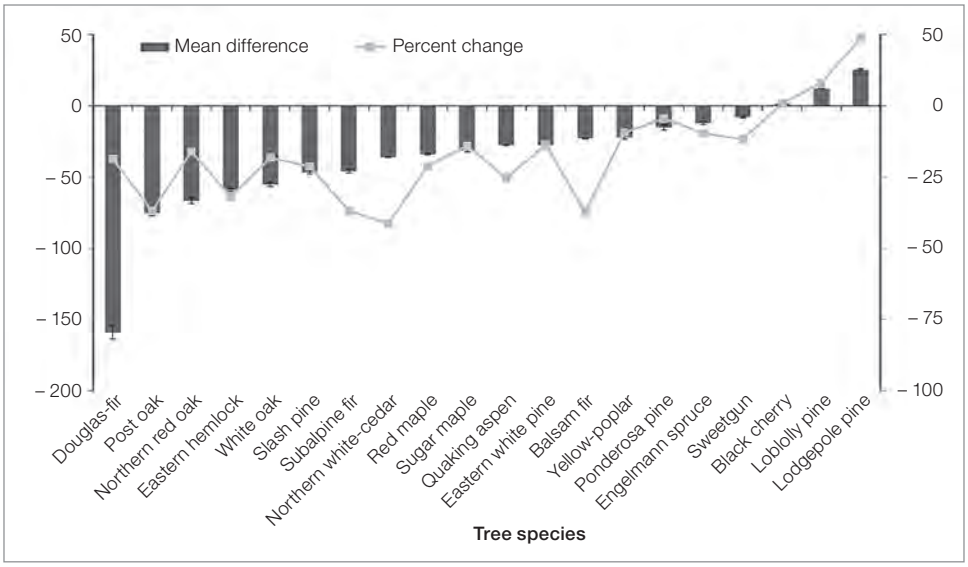
National standing dead biomass (Mg/ha). *Forest Service*

Lead: Northern Research Station

New Tree Volume and Biomass Estimation Procedures Implemented for the Yearly U.S. National Greenhouse Gas Inventory

New procedures have improved the accuracy, reliability, and transparency of the U.S. National Greenhouse Gas Inventory of U.S. forests and biomass assessments

Nationally consistent and documented procedures for estimating forest volume and biomass are central to bioenergy assessments and the yearly U.S. National Greenhouse Gas Inventory developed by the U.S. Environmental Protection Agency (EPA). The Carbon/Timber Product Group of the Forest Service's Forest Inventory and Analysis (FIA) program documented a national approach to tree volume and biomass estimation (Component Ratio Method), evaluated its output in comparison to past methods, and implemented it in the 2012 inventory. Overall, the national evaluation and reporting of standing tree biomass-carbon attributes have been standardized across reporting outlets, such as the EPA, and tools, such as the FIA online data tools. This standardization has improved the accuracy, reliability, and transparency of the yearly inventory of U.S. forests and biomass assessments. The result was achieved by bringing the most recent science and data to bear on each of the standing tree carbon values reported in the inventory.



Mean difference in tree-level carbon stocks between the Component Ratio Method and Jenkins' approach for tree species in the conterminous United States. *Forest Service*

Lead: Northern Research Station

Model Assesses the Influence of Drought Stress on Forests Relative to Other Factors

Drought stress data added to forest landscape disturbance and succession model show that length of drought is more important than severity

Climate change is expected to affect forest landscape dynamics in many ways, but one of the most important direct effects will probably be drought stress. Forest Service scientists used weather and Forest Inventory Analysis (FIA) data to develop equations to predict drought mortality and incorporated them into a landscape forest dynamics model (LANDIS-II). They found that incorporating drought as a tree-killing disturbance indeed does significantly modify forest composition and landscape dynamics. Forest Service scientists combined data from weather stations and forest inventory plots across the upper Midwest to generate predictive equations using measures of drought stress to predict tree biomass lost to mortality for tree species with varying drought sensitivity. These predictive equations were used to develop a drought extension for the LANDIS-II model, which was applied to a test landscape in Wisconsin to assess the influence of drought on forest dynamics relative to other factors such as stand-replacing disturbance and site characteristics (e.g., soil). The simulations showed that drought stress does significantly affect species composition and total biomass. Scientists were able to conclude that, for the upper Midwest, (1) a drought-induced tree mortality signal can be detected using FIA data; (2) tree species respond primarily to the length of drought events rather than their severity; (3) the differences in drought tolerance of tree species can be quantified; and (4) future increases in drought could very well bring changes to forest composition.

Leaf scorch is a drought symptom in linden trees. *Forest Service*

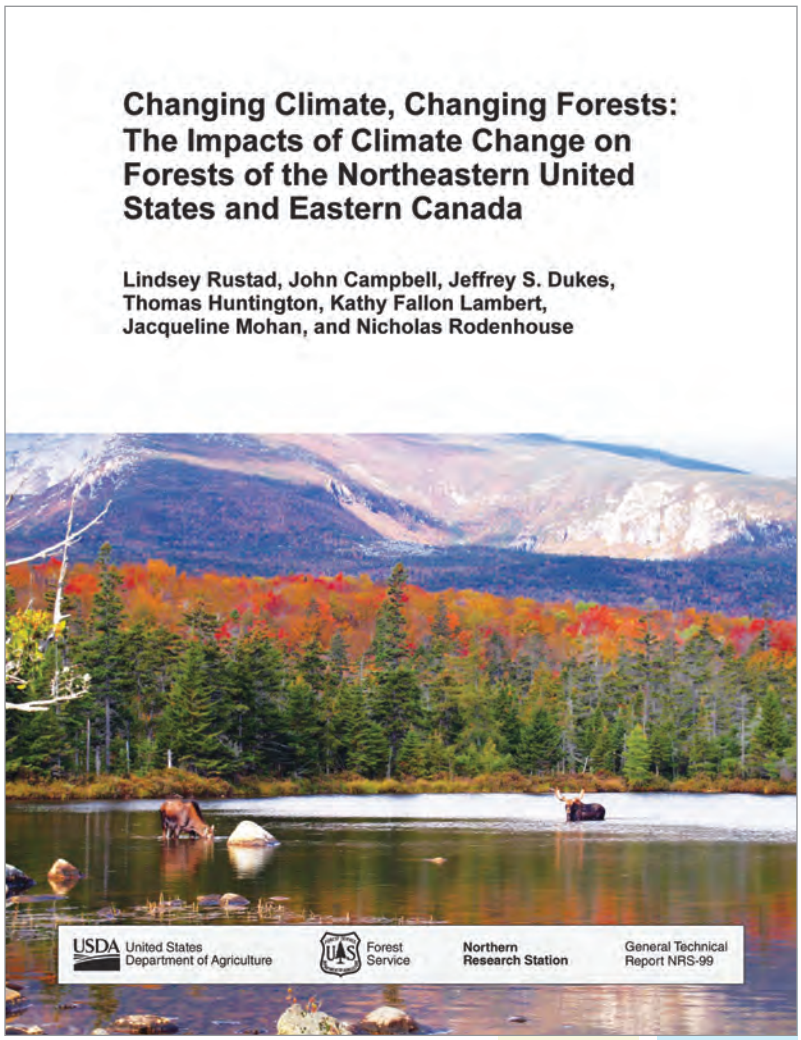
Lead: Northern Research Station

Changing Climate, Changing Forests

Effects of climate change on forests of the Northeastern United States and Eastern Canada

The climate of Northeastern North America has changed markedly during the past 100 years and computer models for the region forecast more change to come. Policymakers, land managers, citizens, and scientists must grapple with what this change means for the future of the region and its forests. Forest Service scientists and a large nationwide team analyzed the extensive literature on the potential effects of climate change on northeastern forest ecosystems and provided a concise scientific overview to inform natural resource management and policy decisions. They found that the evidence is now irrefutable that the climate of the Northeastern United States and eastern Canada has changed in the past century and greater change is projected in the future. These changes have had, and will continue to have, dramatic effects on northeastern forests. Projections include shifts in suitable habitat for forest tree species, with significant declines in the amount of suitable habitat for spruce-fir forests and an expansion in areas that are suitable for oak-dominated forests; changes in forest productivity, with possible gains from extended growing seasons, carbon dioxide, and nitrogen fertilization offsetting losses that are associated with atmospheric deposition of pollutants, forest fragmentation, and forests pests and pathogens; changes in the distribution and abundance of wildlife species through changes in habitat, food availability, thermal tolerances, and susceptibility to parasites and disease; alterations in forest water and nutrient cycling; and expansions in the range and virulence of pests, pathogens, and invasive species. With the accumulating evidence that the climate is changing and the potential effects of those changes, forest stewardship efforts would benefit from integrating climate mitigation and adaptation options into conservation and management plans.

Report cover. *Forest Service*



Lead: Northern Research Station

New Way To Model Forest Stand Dynamics

Scientists test assumptions on natural selection to maximize fitness

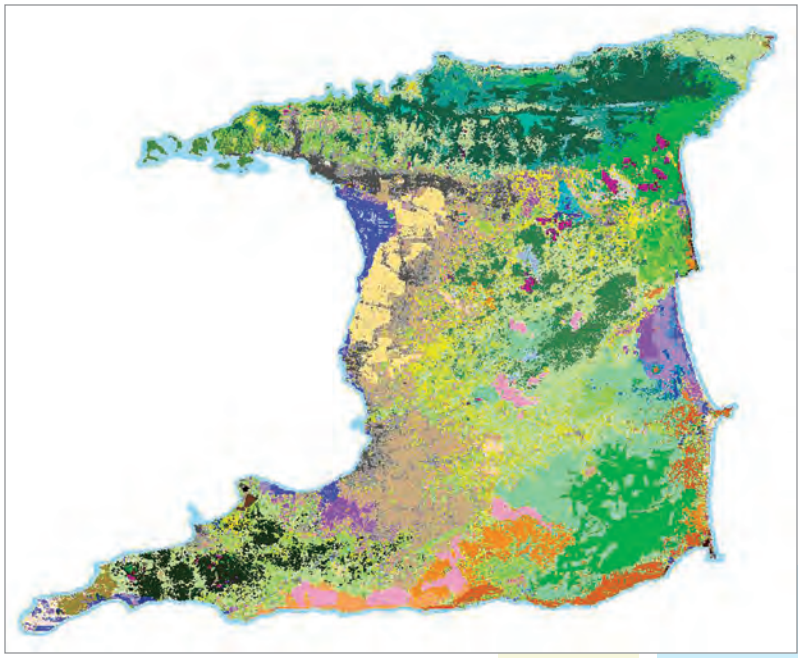
Research models are used to test current theory and advance new ways of formulating forest stand dynamics. Room for improvement exists in our understanding of how the environmentally adaptive traits of trees affect stand growth and, consequently, how we model change through time. To address this gap in knowledge, a Forest Service scientist and a collaborator have created a stand dynamics model that is the first of its kind. Applied models of forest stand dynamics are used routinely to forecast how key forest traits will change through time. Research models, on the other hand, are used to test current theory and advance new ways of formulating models. Fundamentally, a forest is a life system, and a model of forest dynamics is a mathematical formulation of our assumptions and understanding about how that system functions. The Forest Service scientist and a Finnish partner investigated whether this knowledge gap can be circumvented with assumptions based on natural selection. They formulated a dynamic model based on the assumption that, through plasticity in structure and function, trees optimize their acquisition and use of carbon and nitrogen to maximize fitness. They selected height as a proxy of fitness, since the tallest trees in a stand are most likely to survive competitive pressures and produce offspring. The resultant model predicts the optimal pattern by which carbon and nitrogen are coallocated, year-by-year, to the production of new fine roots, leaves, and sapwood. This stand dynamics model is the first of its kind, but predicted leaf and fine-root stocks agree with data from coniferous stands, and the optimal carbon-allocation patterns agree with published observations.

Lead: Northern Research Station

New Study Leads the Way to Detailed Mapping of Tropical Rain Forest Types

Tropical tree communities mapped for Trinidad and Tobago with satellite imagery

A new study shows that widely available satellite imagery can be used to map tropical rain forests with much more detail than was previously thought possible. Although satellite imagery is commonly used to map tropical forests across large areas, only a few forest types are usually identified. This study, however, showed that if many dates of imagery are available, as in newly available satellite image archives, clues to distinguishing among forest patches containing different groups of tree species could be found. Tropical countries need to produce detailed forest maps for a financial mechanism that gives countries incentives for Reducing Carbon Emissions from Deforestation and Degradation (REDD+) and for managing forests to sustain biodiversity and enhance carbon stocks. Detailed maps of forest types, including maps that distinguish groups of tree species, are essential, but until now, scientists have assumed that tropical forest tree communities appear too similar to each other in most satellite imagery to be mapped. Working in the Republic of Trinidad and Tobago, the study authors searched through the recently opened archives of Landsat satellite imagery and through the very high-resolution satellite images that are viewable using Google Earth. They discovered that the spatial distributions of many tree communities, thought to be indistinguishable in satellite imagery, can in fact be revealed, but only in imagery from unique times, such as that collected during periods of severe drought, or when a particular tree species is flowering. Other forest types were distinct in very high-resolution imagery because of unique canopy structure. These maps are the first for an entire tropical country that show the distributions of communities of tropical forest tree species. The study also produced a new set of topographic maps for the country at two scales that depict reserve areas, towns, roads, rivers, and other landscape features in addition to forest type.



International Institute of Tropical Forestry scientists and collaborators mapped 40 forest types plus urban and agricultural areas for Trinidad and Tobago in the first country-wide map of tropical forest tree communities and land cover. *Forest Service*

Lead: International Institute of Tropical Forestry

Outdoor Recreation

The Outdoor Recreation Strategic Program Area is directed at understanding and managing outdoor environments, activities, and experiences that connect people with the natural world. Research within this program area 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.

A High-Tech Adventure Game of Hide and Seek

Geocaching invites a technologically savvy public into nature

"Geocaching" is an outdoor recreational activity where the participants use a Global Positioning System, or GPS, receiver or mobile device and other navigational techniques for treasure hunting with containers, called "geocaches," anywhere in the world. Geocaches are currently placed in more than 197 countries around the world. Forest Service researchers examined the emergence of geocaching as a relatively new technology that is influencing the form and pace of engagement in outdoor recreation. They found that although challenge and skill are part of the adventure offered in geocaching, the draw for most people, regardless of age or whether they geocached as a solitary activity or with a group, was to enjoy outdoor scenery and nature. The researchers developed online support tools and guides to aid land managers in addressing the potential effects of geocaching on a natural setting. The information fulfills an important need to ensure this enticing game that gets Americans outdoors remains available well into the future.

Lead: Pacific Southwest Research Station

Americans and Greeks Experience Similar Benefits From Recreation in Forests

Data show recreational uses of forest lands are psychologically and socially important

Data collected from recreation lists in the United States and Greece shows that recreation experiences in forests are immediately fulfilling and beneficial to enduring issues related to quality of life, an individual's sense of self, and social bonding. Forest Service scientists and their collaborators at Texas A&M University and in Greece report a deeper understanding of the role that outdoor recreation plays in visitors' lives, enabling the benefits of recreation to be evaluated alongside other significant life events. The report shows that outdoor recreation can be restorative and functionally important to everyday life. The data will be increasingly important to policymakers and land managers who must place priorities on recreation and other social benefits of natural areas. The data from the Sumpter National Forest in South Carolina and the Greek city of Thessaloniki demonstrate that, to some extent, these results are universal across cultures and suggest the need to expand comparisons across other related leisure contexts.

Lead: Pacific Southwest Research Station

Latino Community Needs Urban Green Space

Addressing environmental justice in terms of access to urban green space for an immigrant community in Georgia

Park access is considered an environmental justice issue because some research shows that less park acreage is available to minority and immigrant communities, compared with majority white communities. Most Latino settlement in Hall County, GA, has occurred in working class, majority white neighborhoods; therefore, this research considers whether Latinos inherit park acreage. This research examined Latino migration to Hall County, a new destination county in the Southeastern United States, where environmental equity was considered in terms of Latino communities' walking access to public and private parks in the county. This research estimates the number of parkland acres within walking distance of communities in 2000 that had significant Latino, White, and African-American populations. Findings showed Latinos inherited little park acreage relative to amounts available in the county. Results suggest that Latinos must live in more integrated, middle- and upper income neighborhoods to access a greater number of parkland acres. Information from this study can be used to help inform park planning at the municipal and county levels, with a particular focus on improving access for the county's Latino populations. Latino settlement is confined largely to two central-city (Gainesville, GA) census tracts where the amount of land that is available for park conversion is extremely limited. White settlement, on the other hand, extends to the outlying suburbs with more potentially convertible land. Possible strategies to address the relative lack of parkland in higher density Latino communities include converting land from existing uses—such as abandoned landfills, rail yards, or lines to park acreage—or the establishment of land-sharing initiatives whereby neighborhood residents can use schoolyards or even cemeteries for recreation. The most effective strategies for increasing park acreage involve grassroots political engagement. The larger task, however, for city leaders and community organizers is to involve the affected citizenry in decisions about parkland conversion.

A Latino family enjoys a day at the park. *Forest Service*

Lead: Southern Research Station

Study Projects Outdoor Recreation Levels in the United States to 2060

Changes in climate, socioeconomic conditions, and land use, along with population growth will affect future outdoor recreation activity in the United States

Forest Service scientists developed national projections on outdoor recreation participation for 17 activities through 2060. The scientists made projections using a two-step approach to project the number of participants and the number of days of participation under future scenarios that varied by population growth, socioeconomic conditions, land use changes, and climate.

Outdoor recreation will remain a key part of the social and economic fabric of the United States for many decades to come. *Forest Service*

The estimation step yielded national-level statistical models of adult participation rate and days of participation, by activity. The simulation step combined the models with external projections of explanatory variables at 10-year intervals, up to the year 2060. Results were derived across three 2010 Resources Planning Act Assessment scenarios that each feature three associated climate futures. Findings indicated that outdoor recreation would remain a key part of the social and economic fabric of the United States. In the absence of climate change, the number of participants in the 17 recreation activities is projected to increase during the next five decades. In some cases, the participation rate will decline, but population growth will ensure that the number of participants increases. Some climate futures led to projected declines in participants for some recreation activities (e.g., snowmobiling and undeveloped skiing) of up to 25 percent, despite population growth. Climate was also shown to have disparate effects on projections of annual days of participation, particularly for snowmobiling, undeveloped skiing, and hunting.

Lead: Southern Research Station

Updated Computer Model Helps Managers Better Estimate Visitation to Camp Sites

Model simulates travel patterns for 11,000 groups in the Boundary Waters Canoe Area Wilderness

Recreation within the Boundary Waters Canoe Area Wilderness on the Superior National Forest in Minnesota is allocated using a permit system that is designed to avoid congestion and crowded conditions. Visitors to the area can reserve a limited number of overnight permits, must follow travel group size restrictions, and are only allowed to camp at designated campsites. Quotas exist for each wilderness area access point during the heavy use season. These quotas are based on a model that was developed many years ago using information on visitor travel patterns at that time. In 1970, the first efforts were made to build a recreation travel simulation model for this U.S. wilderness area. A second-generation model was developed from itineraries collected in 1980, and the final update was made to that model in 1993. To further update information on visitor travel patterns across this large, heavily used wilderness, Forest Service scientists at the Rocky Mountain Research Station developed a new computer simulation model that predicts campsite occupancy. The model accounts for the unique travel patterns of the 11,000 groups that visit the Boundary Waters Canoe Area Wilderness each summer. The groups choose from 61 entry points and travel through 95 backcountry zones. The model provides a user-friendly interface for interactive modeling, and the modeling can output a variety of estimates about overnight visitor use. The findings will help provide a basis for recreation managers to make decisions about entrance point quotas or to better understand the influence of natural disturbance or management policies that affect travel patterns.

Lead: Rocky Mountain Research Station

Wilderness Fellows Program Engages Youth in Federal Land Management

Program helps agencies develop a baseline assessment of wilderness character and integrate that character in wilderness planning, management, and monitoring

The 1964 Wilderness Act, all subsequent Federal wilderness legislation, and the policies of the four Federal agencies charged with administering wilderness mandate that the wilderness character of these lands must be preserved. These laws and policy do not, however, provide a definition or guidance for what wilderness character is and how to preserve it. To solve the problem, an interagency team, led by the Forest Service's Aldo Leopold Wilderness Research Institute, published *Keeping It Wild*. The publication provides definitions and strategies to understand what wilderness character is and how to assess whether agencies are preserving it over time. To implement this strategy, the Leopold Institute leads a Wilderness Fellows Program to help the agencies develop a baseline assessment of wilderness character and integrate wilderness character into all wilderness planning, management, and monitoring. The Wilderness Fellows Program began in 2010, and, by the end of 2012, a total of 28 wilderness fellows implemented the *Keeping It Wild* strategy in 34 U.S. Fish and Wildlife Service wilderness refuges, 21 National Park Service wilderness parks, and 2 Forest Service wildernesses. The Wilderness Fellows Program provides many different benefits, which include the following:

- Opportunities to engage a diversity of undergraduate and graduate-level students who are keenly interested in careers in Federal land management; these people will become the next generation of Federal land managers and scientists.
- An unprecedented degree of Federal interagency cooperation and coordination, and the resulting increase in efficiency as the agencies work together to implement this program.
- An efficient way to develop a baseline assessment of wilderness character at the particular unit and track it over time. This assessment fosters a deeper understanding among agency staff for what wilderness character is, how it can be preserved, and how it can be used to help staff make more informed decisions.
- An objective, comprehensive, and transparent way to evaluate agency accomplishment in fulfilling the congressional mandate and agency policies to preserve wilderness character, thereby improving communication among staff and with the public about the benefits of an enduring resource of wilderness.

Members of the Wilderness Fellows Program. *Forest Service*

Lead: Rocky Mountain Research Station

Study Assesses Public Access to Private Land for Recreation Purposes

Scientists review opportunities, constraints, and possibilities for relieving recreational pressure on public lands

Participation in outdoor recreation in the United States is increasing while the amount of public land available for recreation has remained largely static. Access to private rural lands has been advocated as a means of alleviating recreational pressures on public lands. Using the Forest Service's National Woodland Owner Survey, Forest Service scientists examined several questions: (1) How prevalent is public recreational access on family forest land? (2) What factors influence whether a family forest owner allows public access? (3) Do regional differences exist in the supply of public access? The scientists found that the provision of public recreational access was modest, with 15 percent of respondents allowing it. Factors positively correlated with public access included owning more forest land, being a resident owner, owning an associated farm or ranch, participating in leasing or timber management, and having a management plan. Negative factors included posting the land, having privacy concerns, owning land for hunting, and being an older or more educated owner. Compared with northern region landowners, southern region landowners were less likely to provide public access, and Rocky Mountain region landowners were also more likely to provide public access. These results raise the question of whether family forest landowners are aware of or responsive to Government-sponsored incentive programs that are designed to promote public access to private lands.

Private forest land posted against unauthorized public access. *Forest Service*

Lead: Northern Research Station

From World's Largest Landfill to New York City's Newest Park

The story of the restoration of Fresh Kills Salt Marsh, Staten Island, NY

Located at the southwestern corner of Staten Island, NY, the Fresh Kills Salt Marsh became the world's largest landfill. The New York City (NYC) Department of Parks and Recreation is converting the landfill into a park and citywide cultural destination through extensive ecological restoration and landscape planning efforts. At 2,200 acres, Freshkills Park is the largest park developed in NYC in more than 100 years. Forest Service scientists from the NYC Urban Field Station partnered with the city to document and study the park's creation and exploring social and biophysical processes during the conversion. Staten Island residents' attitudes towards the park were assessed, and students in the 2012 Columbia University Master of Science in Sustainability Management Capstone Workshop developed a communications strategy to address public health concerns surrounding Freshkills Park. In another project, "Legacies of the Dump," the NYC Urban Field Station and Freshkills Park staff used focus groups to understand Staten Island residents' memories of the landfill and their fears and interests in using the future park. Additionally, another study is propagating native poplar and willow plants collected from Staten Island at the Institute for Applied Ecosystem Studies in Rhinelander, WI. These trees will be grown in a greenhouse and hybridized, and the most successful genotypes will be outplanted at Freshkills Park.

Kayakers in Freshkills Park, New York City. *Forest Service*

Lead: Northern Research Station

Scholars Program Welcomes Youth Into the World of Nature

Alleviating "nature deficit disorder" in the youth of Wisconsin's Northwoods

The Northwoods Environmental Scholars Program fosters awareness of science and natural resources in the youth of Wisconsin's Oneida County. Through supervised field projects, field trips, and classroom exercises, high school students learn about environmental conservation disciplines such as water quality and wildlife biology. The mentoring program consists of multiple field-based projects and a small-scale scientific study to highlight the power of observation and data collection. Oneida County is known as the region of Wisconsin's Northwoods—"Where nature lingered longer." Despite the county's nearly 560,000 acres of forest land and 1,100 lakes and streams, area youth follow the national trend of "nature deficit disorder," gravitating away from outdoor experiences and towards a virtual, sedentary indoor reality. The Northwoods Environmental Scholars Program is a partnership of the Forest Service's Rhinelander Laboratory, Rhinelander High School, Wisconsin Department of Natural Resources, University of Wisconsin, and Iowa State University. The program's long-term objectives are to provide high school students with outdoor experiences and opportunities related to science and natural resources, thus increasing environmental awareness and excitement among local youth. The students take part in office, lab, and field investigations that discuss natural resource topics that include water quality, wildlife biology, phytotechnologies, renewable energy, energy crop production, climate change, silviculture, tree genetics, and entomology. When possible, they present their experiences at the Governor's High School Conference on the Environment that is organized by the Wisconsin Center for Environmental Education at the University of Wisconsin, Stevens Point.

Northwoods Environmental Scholars group. *Forest Service*

Lead: Northern Research Station

Resource Management and Use

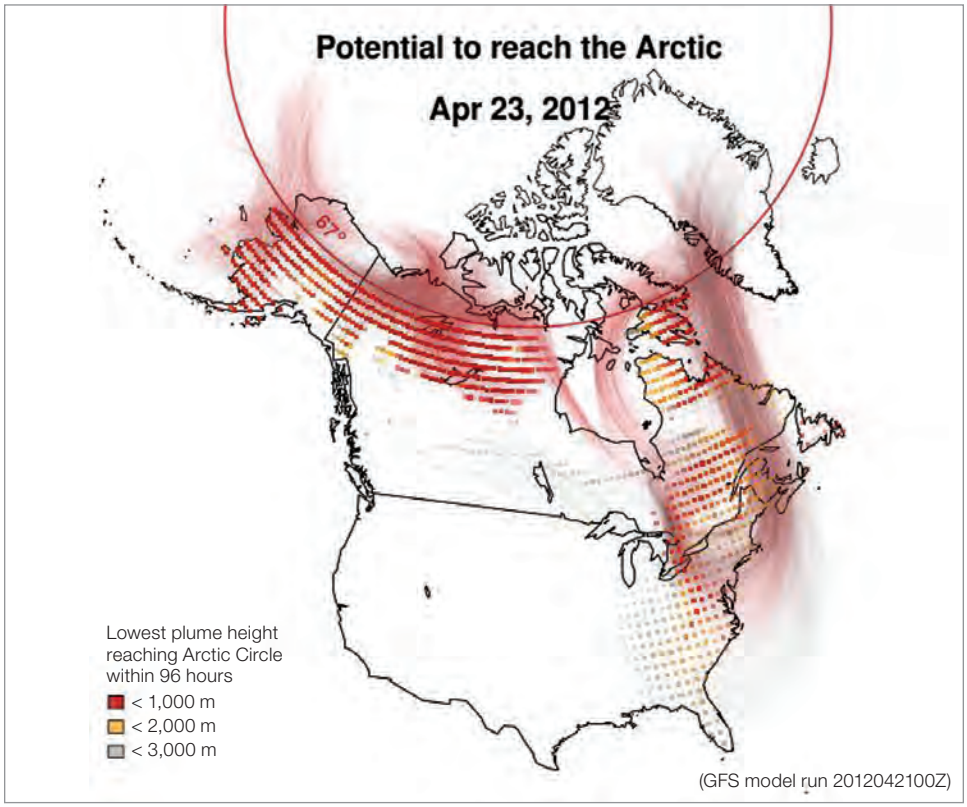
The Resource Management and Use Strategic Program Area provides a scientific and technological base to sustainably manage and use forest resources and forest fiber-based products. Research areas include plant science, soil science, social science, silviculture, productivity, forest and range ecology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

Mitigating Arctic Black Carbon Deposition

Scientists identify meteorological conditions when black carbon does not travel to the Arctic

A new study of the ability of emissions to be transported to the Arctic is providing managers and policymakers with information relevant to mitigating Arctic black carbon deposition from the United States. Black carbon is the sooty particulate matter produced by incomplete combustion of fossil fuels, biofuels, and biomass which readily absorbs sunlight and warms the atmosphere. When black carbon is deposited on snow, it absorbs light and heat and accelerates melting. This study used 30-year climatology of atmospheric transport patterns along with a real-time forecasting system. Scientists found that even in locations and during seasons where emissions can be quickly transported to the Arctic during normal conditions, a number of timeframes still exist when Arctic transport does not occur. By refocusing prescribed burning and other emission activities into these timeframes where transport does not occur, mitigation of Arctic black carbon deposition is possible.

This work was used in the U.S. Environmental Protection Agency's Report to Congress on Arctic Black Carbon, finalized in May 2012. The work identified ways to mitigate Arctic black carbon deposition and yet avoid seasonal bans on prescribed burning. This work was also presented at a meeting in Moscow with the Russian Engineering Academy of Management and Agrobusiness.



Daily prediction of atmospheric black carbon originating in the United States transported to the Arctic. *Forest Service*

Lead: Pacific Northwest Research Station

Responding to Climate Change on National Forests

A new guidebook provides a scientific foundation and framework for preparing for climate change

Forest Service scientists and collaborators developed a climate change guidebook using a science-management partnership approach. "Responding to Climate Change in National Forests: A Guidebook for Developing Adaptation Options" provides information on climate change education and explains how to conduct vulnerability assessments and adaptation planning for forest lands. It describes various tools and processes that have been tested in national forests and provides supporting scientific documentation. The guide is now used throughout the National Forest System and by other Federal agencies and institutions to assist with implementation of climate change adaptation practices. It is the basis for adaptation principles and applications cited in the forest sector technical report for the 2013 U.S. Global Change Research Program National Climate Assessment.

Lead: Pacific Northwest Research Station

Scientists Find Cause of Yellow-Cedar Death in Alaska's Coastal Forests

Absence of snow to protect shallow roots results in roots freezing and extensive tree death

Yellow-cedar decline has affected about 60 to 70 percent of trees in forests covering 600,000 acres in Alaska and British Columbia. The cause of this extensive tree death, called yellow-cedar decline, is now known to be a form of root freezing that occurs during cold weather in late winter and early spring when snow is not present on the ground to protect fine roots. Yellow-cedar's shallow rooting, early spring growth, and unique vulnerability to freezing injury contribute to its decline in Alaska's coastal forests. The tree thrives in wet soils, but its tendency to produce shallow roots to access nitrogen on these sites makes it more vulnerable to fine root freezing when spring snow levels are reduced by a warmer climate. Yellow-cedar health depends on changing snow patterns, thus, locations for appropriate conservation and management activities need to follow the shifting snow patterns on the landscape. Forest Service scientists synthesized 30 years of research and offer a conservation strategy framework for yellow-cedar in Alaska. The scientists are working with Federal land managers in Alaska to use this new information as the framework for a comprehensive conservation strategy for yellow-cedar in the context of a changing climate. Coastal Alaska is expected to experience less snow but will retain a persistence of periodic cold weather events in the future. Current and future yellow-cedar health can be predicted in landscapes based on observed patterns of snow and soil drainage.

Yellow-cedar's shallow roots make it vulnerable to freezing injury in spring when snow is not present to provide insulation. *Forest Service*

Lead: Pacific Northwest Station

Heating With Wood in Alaska

Converting oil heating systems in residential and commercial buildings in Alaska to renewable wood energy would require 1.3 to 1.7 million cords of wood a year

Developing new markets for bioenergy is an important component of the Forest Service's objectives to sustain healthy forests and address the effects of climate change. A recent study attended to the information needs of forest managers, entrepreneurs, and civic officials who are interested in using various forms of local biomass as energy sources. Given the high transportation costs of importing products to Alaska, local markets are an important part of any business plan to produce energy products. The total volume required to convert oil or other liquid fuels used by the Alaska residential and commercial sectors to renewable wood energy is equivalent to the amount of wood needed to supply raw material to one large pulp mill annually. The economic incentive to convert to solid wood fuel exists at any heating oil price above $3.00 a gallon.

Firewood for home heating.
Forest Service

Lead: Pacific Northwest Research Station

Finding Value in Young-Growth Koa Wood

A demonstration project informs the forest industry in Hawaii of the quality and uses for young-growth Koa wood

Koa wood is a culturally important and economically valuable species on the Hawaiian Islands. It is used for a range of products from flooring to ukuleles. Old-growth koa, used for manufacture of traditional Hawaiian wood products, is dwindling in supply with limited amounts available in the coming years. Thousands of acres of young (less than 30 years old) koa stands, however, have naturally regenerated after logging and other disturbances, yet limited data are available for these second-growth koa stands. Active management of these stands will make small-diameter young-growth trees available within the next 5 years. Two studies have evaluated the quality and attributes of dead and dying old-growth koa and young-growth koa. Young-growth trees were sawn into lumber, and woodworkers used the lumber to demonstrate its quality characteristics in a number of different products. These studies extend the legacy of koa wood by demonstrating properties of this wood and promoting its use. The manufacture of traditional products for display and use in public institutions and cultural resource centers has allowed a broader public to register their opinions on the quality and potential value of wood from younger koa trees.

A koa log. *Forest Service*

Lead: Pacific Northwest Research Station

Managing for Ecosystem Services on Public Land

New report provides an overview of how national forests can address ecosystem services and tradeoffs associated with forest management plans and projects

In response to the new forest planning rule, the Forest Service has formally adopted the concept and language of ecosystem services as a way to describe the beneficial outcomes of national forest management. A new report reviews the economic theory of ecosystems services as it applies to public land management under the new planning rule and considers what the theory implies about the types of biophysical and other data that are needed for characterizing management outcomes with changes in ecosystem services.

The report serves as a guide to policymakers, managers, researchers, and others who evaluate and describe the tradeoffs involved in the methods used to manage public lands. The Forest Service Ecosystem Services Valuation Working Group is using the report to develop a technical advice bulletin for Forest Service staff. The technical advice bulletin will guide national forest staff in their efforts to consider the relative contributions and values of ecosystem services in forest planning and other decisionmaking situations.

The Klamath Marsh National Wildlife Refuge provides a wide variety of ecosystem services including clean water and air, wildlife habitat, and scenic beauty. *Forest Service*

Lead: Pacific Northwest Research Station

New Report Assesses the Effects of Climate Change on Forest Diseases

Climate change is projected to have far-reaching environmental effects domestically and abroad

A recently published Forest Service report examines the effect of climate change on forest diseases and how these pathogens will ultimately affect forest ecosystems in the Western United States and Canada. A "Risk Assessment of Climate Change and the Impact of Forest Diseases on Forest Ecosystems in the Western United States and Canada" report explains fundamental relationships between tree diseases and climate conditions that will help land managers and others determine how local conditions may influence tree survival. Drawing on a large body of published research, the report details the effects of eight forest diseases under two climate-change scenarios—warmer and drier conditions and warmer and wetter conditions. The forest diseases discussed in the report include foliar diseases, *Phytophthora* diseases (such as sudden oak death), stem rusts, canker diseases, dwarf mistletoes, root diseases, and yellow-cedar decline. The likelihood and consequences of increased damage and mortality to forests from each disease as a result of climate change were analyzed and assigned a risk value of high, moderate, or low. The scientists predict *Armillaria* root disease will cause the greatest risk to forest ecosystems under warmer and drier drought conditions. *Armillaria* is common on conifers and some hardwoods; it lives on tree roots and grows exponentially when a tree becomes stressed. Yellow-cedar decline, Cytospora canker on aspen, and dwarf mistletoes also pose high risk under drought conditions. Sudden oak death and other *Phytophthora* tree diseases are likely to be most damaging under wetter and warmer conditions. These deadly pathogens reproduce and spread quickly under favorable moist and warm conditions. Tree diseases shape America's forests, according to the scientists. Understanding how climate change will affect the diseases is paramount to sustaining healthy forests.

Lead: Pacific Southwest Research Station

Effects of Rising Temperature on Carbon Cycling and Storage in Ecosystems

Scientists find that as ecosystems warm, they store more carbon, not less

Earth's increasing temperatures may have large effects on ecosystem carbon process rates and storage in soils and vegetation, but a quantitative understanding of these effects remains elusive because realistic studies are hard to construct. Artificial heating studies typically warm only the soil and miss replicating the effects on the whole ecosystem. Forest Service scientists and their partners at the University of Hawaii at Manoa used a highly constrained mean annual temperature gradient in Hawaii where soils, vegetation, stand characteristics, natural forest disturbance history, and soil moisture are all highly controlled. Coupling this gradient with detailed mass and radiocarbon-based measurements of the soil, litterfall, and growing vegetation, the scientists found that as ecosystems warm, they store more carbon, not less. Part of the reason for this relationship is that soil carbon decomposition does not accelerate with warming while stand productivity increases. The research findings suggest there will not be a positive feedback on warming due to accelerated loss of carbon from soils to the atmosphere. This research benefits ecosystem and climate change modelers who try to refine projections for potential feedbacks by the terrestrial biosphere on the atmosphere. It has implications for forest management and policymaking sectors, as forests can play an important role in the long-term storage of carbon. Projections that show a positive feedback on warming that ranges from an accelerated carbon loss point to an ultimately more costly approach to mitigating warming—and so this research may provide economic benefits to society as countries prepare for development and adoption of mitigation strategies. This ongoing research occurred on the windward side of Hawaii Island between 2008 and 2012 and will continue through 2015.

Lead: Pacific Southwest Research Station

Report Offers New Management Strategies for Sierra Nevada Forests

Concrete examples of science-based strategies are a hit with managers and stakeholders

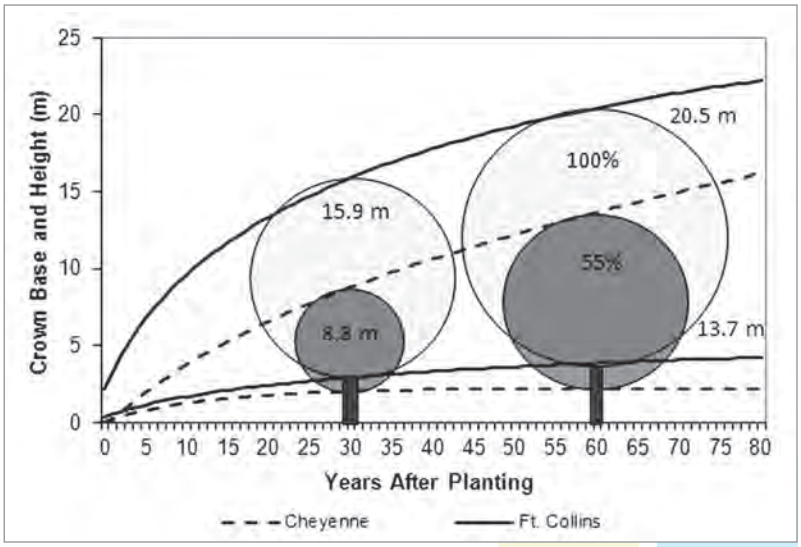
It is typical for managers to resist new land-management practices because they think that the changes are too difficult, too costly, or too time consuming to implement. A set of examples and discussions presented in a Forest Service report, "An Ecosystem Management Strategy for Sierran Mixed-Conifer Forests," offers managers concrete examples of how to implement new science-based management strategies with stakeholder involvement. The report, which clarifies land-management concepts and summarizes recent relevant science, is endorsed by a diverse array of stakeholders. As a result of positive reception to the report, the pace and scale of forest treatments using the new methods has picked up. Examples presented in the report are from ongoing, successful projects throughout the Sierra Nevada. Summaries of recent science in the fields of climate change, bark beetles, fire and fuels, and sensitive species habitat provide strong scientific support for these new management practices. The 26 authors who contributed information to the report include Forest Service scientists and managers, scientists from the University of California at Berkeley and Davis, California State University Sacramento, the U.S. Geological Survey, and a private stakeholder.

Lead: Pacific Southwest Research Station

New Model Predicts Urban Tree Growth

New study developed growth equations for urban tree species throughout the United States

Large trees are often desirable in urban settings because they provide more shade, erosion control, and other ecosystem services than small trees, but the science of predicting tree size is hindered by too few long-term studies that track tree growth and a poor understanding of how multiple stressors affect tree health. A Forest Service study that began in 1998 in cities representing 16 climate zones has resulted in growth equations for urban tree species throughout the United States. This research on urban tree growth improves the accuracy of models that quantify urban forest function and value. The research helps managers select, locate, and manage trees to more effectively cool urban heat islands, conserve energy, filter air pollutants, reduce runoff, sequester carbon, and promote human well-being. Greater awareness of tree benefits, increased investment in tree management, and more productive urban forests are resulting from this science. The scientists developed more than 1,800 growth equations from measurements on more than 17,000 trees in 16 U.S. cities. For each reference city, the scientists produced a "Municipal Forest Resource Assessment" that quantified annual benefits and costs. A "Community Tree Guide" and a brochure, "Trees Pay Us Back," were produced for each of the cities. This information is based on the 40-year benefits and costs of typical large, medium, and small trees and has been widely used to show the value of healthy trees. For example, groups of people monitoring trees use the Forest Service data for "price tags" attached to legacy trees that display the dollar value of ecosystem services produced. The study's tree growth research is central to many computer models used in urban forestry, such as i-Tree Streets, i-Tree Design, National Tree Benefit Calculator, and Open Source Map. A tree growth database will be complete in 2013 and serve as a valuable source of information that reflects regional differences in species composition, climate, soils, site conditions, and management practices. In 2011, the lead scientist for this study was instrumental in establishing the International Society of Arboriculture's first working group on Urban Tree Growth & Longevity. As the chair of this group, he convened the Urban Tree Growth and Longevity Conference in 2011 at the Morton Arboretum in Lisle, IL, and a year later, the Urban Tree Monitoring Symposium in Portland, OR. These international conferences brought researchers and practitioners together to discuss the current state of knowledge concerning urban tree growth and monitoring. Two special issues of the *Journal of Arboriculture & Urban Forestry* contain papers presented at the conference.



Tree height, crown base, and leaf area for same-aged green ash in Fort Collins, CO, and Cheyenne, WY. Upper lines represent height, lower lines represent height to first branch. Ash trees have only 55 percent of the Fort Collins' ash leaf area, largely due to differences in climate and soils. *Forest Service*

Lead: Pacific Southwest Research Station

Understanding Effects of Bioenergy Harvesting in Southern Forests

Woody biomass utilization offers the potential to remove and use more of the total volume in southern forests

As a new wood-to-energy market develops, concerns exist in regard to the expanded removal of forest biomass. Biomass harvesting technology can recover and use many forms of woody material, and some potential conversion processes can accept any organic material including shrubby and herbaceous biomass. A number of States have developed biomass removal guidelines specifying retention of a certain proportion of material, and these are generally consensus recommendations, however, there is a lack of solid data from actual field operations. Forest Service researchers have examined the collection efficiency of biomass harvesting operations ranging from mulching and baling to whole-tree clearcutting. The researchers tested mulch and bale machines in conditions as varied as pine plantation understory to juniper woodlands, and less than 50 percent of potential understory shrub and herbaceous biomass was recovered in bales. Additional studies of whole-tree clearcutting revealed that of the total preharvest aboveground biomass, about 83 percent was recovered in clean chip volume and another 4 percent was recovered in biomass residues, leaving 13 percent (26 green tons per acre) onsite as nonrecoverable biomass. Researchers also collected destructive biomass samples to determine nutrient and carbon mass balance. Harvesting operations are still limited by tree and equipment conditions, however, and full utilization is not technically feasible. This research documented actual biomass recovery in pine plantation clearcuts and found a 4-percent increase in removal volume. Further work will quantify nutrient losses.

Chaining a pinyon tree to a crane scale. *Forest Service*

Lead: Southern Research Station

Red Oak Species Is Especially Vulnerable to Drought Events

Oak decline and mortality under periodic regional drought in the Ozark Highlands of Arkansas and Missouri

Data from 6,997 Forest Inventory and Analysis plots were used to examine oak decline and mortality trends for major oak species in the Ozark Highlands of Arkansas and Missouri. Oak decline was greater in the red oak species whose values were three to five times higher than for white oak and nonoak species. In fact, the white oak group has maintained a relatively stable mortality rate that is comparable to nonoak species. Analyses indicate that mortality in the red oak group was significantly connected with the growing season Palmer Drought Severity Index (PDSI) and usually lagged 2 to 3 years behind single drought events. PDSI is a measurement of dryness based on recent precipitation and temperature. Moreover, based on the past 17 years of PDSI data, it appears that the cumulative effects of drought may persist up to 10 years. The Ozark Highlands experienced a severe drought extending from 1998 to 2000 and another milder drought from 2005 to 2006. These drought events triggered the escalation of red oak mortality starting around 2000. Given that drought is a factor for increased mortality, forest resource managers should plan forest management activities to mitigate the effects of drought. Since older, denser stands have shown an increase in mortality, forest managers could increase forest age diversity. During or immediately after future severe drought events, forest managers could elect to harvest trees that are more susceptible to mortality to avoid losses. Mortality rates increased further in the Ozark Highlands after the onset of a second drought event in 2005. Perhaps those trees were affected by the first drought event and did not have sufficient time to recover. Additional research could attempt to incorporate previous periods of drought into a model to predict the likelihood of mortality associated with sequential drought events because, in the Ozark Highlands, drought has been shown to be an inciting factor that leads to increased levels of mortality.

The brownish areas are oak decline sites/trees. *Forest Service*

Lead: Southern Research Station

Restoration Treatments for the Post-Hurricane Recovery of Longleaf Pine

Scientists recommend herbicide use to control hardwoods in plantings of longleaf pine after hurricane damage

Hurricane Ivan's destructive force leveled some research plots in the Escambia Experimental Forest in southern Alabama. Scientists decided to use these same plots to launch a new research study exploring the use of herbicides on longleaf pine recovery from the hurricane's disturbance. Since 2004, the scientists have been testing several combinations of site preparation treatments to assess the efficiency with which they aid in the recovery. Groups of plots were treated with herbicide, burned, planted, and then fertilized. Herbicide treatment of hexazinone, triclopyr, or imazapyr for competition control, and fertilizer treatments of phosphorus and potassium to stimulate growth of planted longleaf pine seedlings are being evaluated against untreated control plots. All plots were initially burned with prescribed fire to reduce logging slash and will be burned once every 3 years. Early findings indicate hardwood trees and shrubs expand quickly in open areas and dominate pine seedlings unless controlled with herbicide. Although prescribed burning alone can control hardwoods effectively beneath the forest canopy, in open areas, the abundance of light and scarcity of fine fuel to support sufficiently intense prescribed fires is less effective for controlling hardwoods than the combination of a single herbicide application followed by periodic surface fire. Understanding such relationships will provide forest managers with useful approaches for promptly restoring longleaf pine after hurricane disturbance and salvage logging.

Herbicide-treated plot where planted longleaf pine seedlings are free to grow with minimal competition from hardwoods. *Forest Service*

Lead: Southern Research Station

"In-Filling" Reduces the Urban Forest to the Detriment of Humans and Wildlife Habitat

The urban landscape, because of its developed infrastructure, has less ecological services than a forested rural landscape, and any further erosion of its remaining services may be detrimental to humans

The urban forest is highly dynamic. Losses result from droughts, wind and ice storms, land development, and potentially from management activities. Gains result from natural regeneration, canopy expansion, and growth of plantings. When losses exceed gains, a net loss of ecosystem services, such as shading and social, cultural, and health benefits, occurs. "In-filling" is when a forest or existing urban land use in a city is converted into a different urban land use which can result in the reduction of the urban forest. For example, the conversion of residential land use or a forested vacant lot to commercial or transportation land use often results in the reduction of the urban forest. An analysis of canopy cover of the Gwynns Falls watershed in Baltimore and Baltimore County, MD, from 1994 to 1999, showed a reduction in canopy cover, not only in the county from deforestation practices but also in the city from in-filling practices. The loss of urban forest in the city showed a direct reduction of estimated benefits. Although in-filling may increase efficiencies for residents and reduce land development in less developed areas, continual in-filling can be especially problematic when considering human health and comfort and potential loss of valuable habitat for native species.

The urbanization of forests. *Forest Service*

Lead: Southern Research Station

Report Investigates Connection Between Urban Green Spaces and Environmental Justice

Ecosystem services from urban green spaces have numerous benefits for the landscape and public health

Urban green spaces provide ecological services that influence human health, and disproportionate access to the health benefits of green spaces may promote environmental health inequalities. This review of the literature, focusing on the connection between urban green space access and environmental justice, discusses the dynamics of the relationship as it relates to factors such as environmental quality, land use, and environmental health disparities. Urban development stresses the landscape and may compromise environmental quality. Because some communities are disproportionately affected by changes in land use and land cover, understanding environmental justice implications of changing the landscape is important. The review synthesizes information from a range of disciplines—urban ecology, sociology, public health, and environmental science—to address collective concerns related to green spaces and environmental justice. The review also articulates a gap in the literature related to empirical research on the subject.

Children join in a game of tug of war. *Forest Service*

Lead: Southern Research Station

Research Helps Conserve and Restore Shrub-Dominated Ecosystems

Helping to make prudent, research-based decisions to improve shrublands in the Interior West

Shrubs are the cornerstones of arid ecosystems in the West, mitigating soil erosion, fostering plant and animal biodiversity, storing carbon, and providing cover and forage for wildlife, such as the greater sage-grouse—a recent addition to the candidate list of threatened species. These shrub-dominated ecosystems are being compromised, however, by increased fire frequency and size, coupled with encroachment of invasive plants. Subsequently, post-fire restoration has become a fundamental component for maintaining eco-system function and resiliency in these shrublands. Many of the restoration plantings currently used in the Intermountain West include big sagebrush seed collected from naturally occurring populations. In addition, increased wildfire frequency and the introduction of invasive annual grasses in the Mojave and Colorado Plateau have increased the need to restore blackbrush ecosystems. Shrubland restoration through wildland plantings is most effective when the plant materials used are site-adapted and have appropriate levels of genetic diversity promoting resilient ecosystems, now and in the future. Moving plant materials responsibly requires knowledge of how plant populations and species are adapted across variable environments. Studies in which plants representing multiple populations of a single species are grown together in common environments provide a useful approach for ascertaining species limits. Two common gardens have been established for big sagebrush and blackbrush at the Great Basin and Desert Experimental Ranges in Utah, respectively. These experimental areas are ideal for these studies because of naturally occurring shrub-dominated vegetation, historical and ongoing weather data collection, and protection from livestock use. To date, dramatic differences have been observed among big sagebrush and blackbrush populations in the experimental range's common gardens. For both species, mortality has varied from 0 to 100 percent after 3 years. In the case of blackbrush, DNA (deoxyribonucleic acid) data support common garden observations made by researchers, which suggests that this species has two ecotypes or metapopulations that group geographically to the Mojave Desert and Colorado Plateau regions. For example, mortality of Mojave plants at the Desert Experimental Range, which climatically resembles the colder Colorado Plateau, reached nearly 90 percent after a recent, unusually cold winter when compared with the 20-percent mortality rate for Colorado Plateau plants. These results help land managers make prudent, research-based decisions on seed transfer protocols in the event of climate change.

Healthy sagebrush common garden at Great Basin Experimental Range. *Forest Service*

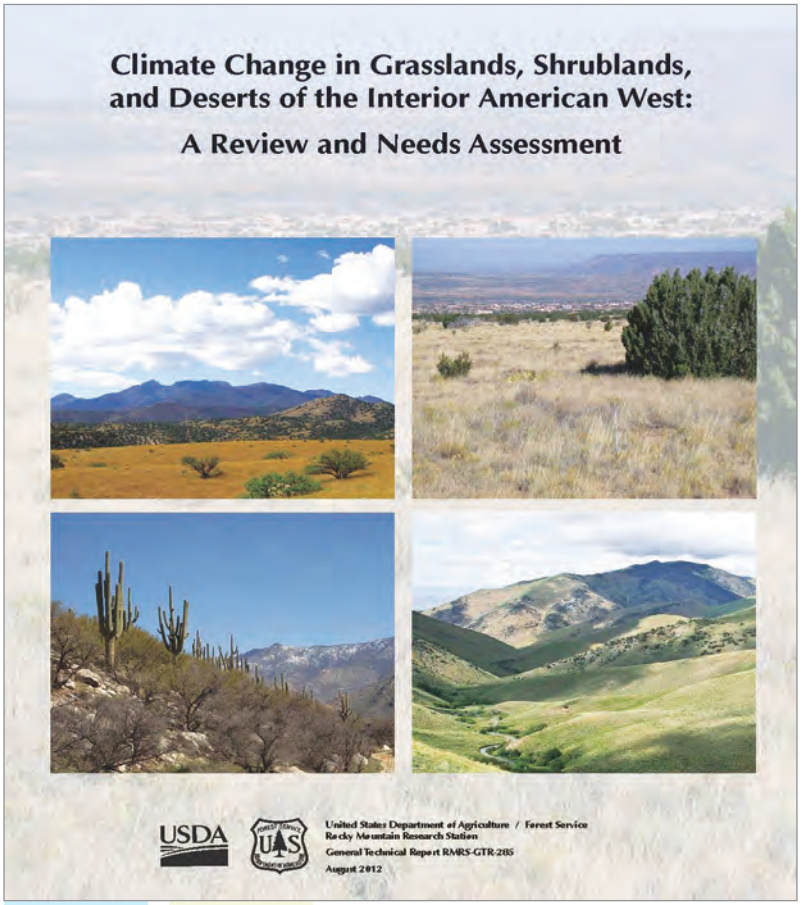
Lead: Rocky Mountain Research Station

The Effects of Climate Change in Grasslands, Shrublands, and Deserts

Studies show that by the turn of the century, climate in the Western United States may be incompatible with current vegetation types, resulting in shifting patterns of terrestrial ecosystems

Forest Service scientists recently published a comprehensive report summarizing climate change research and its potential effects on grassland, shrub, and desert ecosystems. The report, "Climate Change in Grasslands, Shrublands, and Deserts of the Interior American West: A Review and Needs Assessment," highlights current knowledge and suggests future research that will be essential to mitigate the prospective detrimental effects of climate change. It addresses animal, plant, and invasive species models and responses; vulnerabilities and genetic adaption; animal species and habitats; and decision-support tools for restoration and land management. Findings from the report reveal that, by the turn of the century, climate in the Western United States may be incompatible with current vegetation types, resulting in shifting patterns of terrestrial ecosystems. In arid and semi-arid shrublands and deserts, invasive grass species with higher flammability like cheatgrass will spread and increase fire frequency and extent. Increased temperatures may affect insect development time and result in significant increases in generations per year/per habitat and expose new environments to colonization. Increased water scarcity—such as disruption of water flow regimes and river and wetland drying—are likely to become overriding conservation issues.

Report cover. *Forest Service*

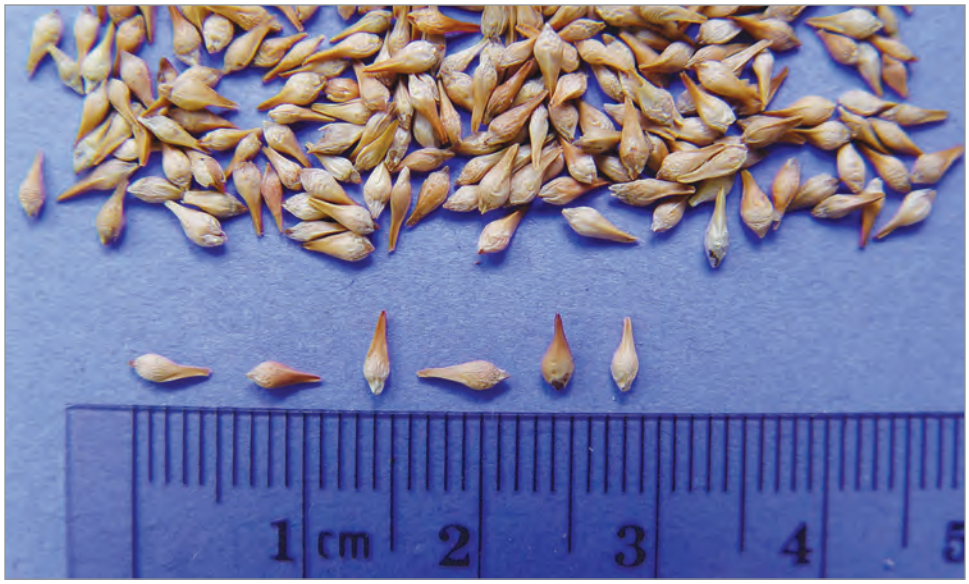


Lead: Rocky Mountain Research Station

Scientists Conserve the Seeds of Today for the Best Adapted Plants of Tomorrow

Project is aimed at restoring damaged grasslands, shrublands, and deserts

Faced with extensive disturbances and climatological challenges that are rapidly changing ecosystems, scientists and land managers require the seeds of today to provide the plants of tomorrow. Researchers are currently studying more than 50 plant species in order to select the best adapted plants to current and future climate conditions. Forest Service scientists, in partnership with the Bureau of Land Management's Seeds of Success Program, are providing the resources necessary to restore damaged grasslands, shrublands, and deserts—especially in the sagebrush ecosystem. For commonly used restoration species, goals of the program are to ensure genetically diverse, regionally adapted plants, especially forbs, for reestablishing degraded landscapes, and that sufficient knowledge and technology is available to plant self-sustaining native communities on disturbed sagebrush rangelands. Researchers evaluate each plant's likely contribution to improving habitat for more than 300 common and rare plant and animal species that depend on the sagebrush ecosystem. Along with cooperators, researchers have collected native grass and forb seed at more than 2,000 sites during the past 10 years. In addition to using the seed collections for research, when collection size permits, the researchers provide 10,000 seeds to the Seeds of Success program for deposit in the USDA Agricultural Research Service National Plant Germplasm System along with site details, photographs, and herbarium specimens. Preserving seeds has inherent value in the retention of the DNA (deoxyribonucleic acid) of native plants that are at a risk of loss because of ongoing disturbances and provides a library of plants' genetic material. This effort makes a variety of seeds available to sustain seed supplies for restoration on future landscapes.



Sulphur-flower buckwheat seed. *Forest Service*

Lead: Rocky Mountain Research Station

U.S. Urban Tree Cover Declining

Analysis of aerial images reveals that U.S. urban areas are losing about 20,000 acres of tree cover per year

Trees in urban areas provide numerous benefits to city residents. Forest Service scientists found that, in recent years, urban tree cover has been declining at a rate of about 20,000 acres per year or about 4 million trees per year. Trees in urban areas provide numerous benefits related to air and water quality, air temperatures, energy use, social well-being, and human health. Numerous forces, however, such as urban development, insects and diseases, natural regeneration, and tree planting, are constantly challenging the urban forest and landscape. Recent analyses by Forest Service scientists of urban tree cover nationally reveal that urban tree cover is on the decline and that urban areas affect regional tree cover positively and negatively.

At a national level, urban tree cover in the latter part of the last decade has declined at a rate of about 20,000 acres per year or about 4 million trees per year. Most of the cities that were analyzed revealed a loss in tree cover that averaged about 0.3 percent of the city area per year. Although tree cover is declining within most urban areas, the development of some urban areas can increase regional tree cover, especially in grassland-dominated States. Thus, the process of urbanization is changing regional tree cover while tree cover in already established urban areas is on the decline. Understanding these changes is leading to better management plans to sustain tree cover and their associated benefits for current and future generations.

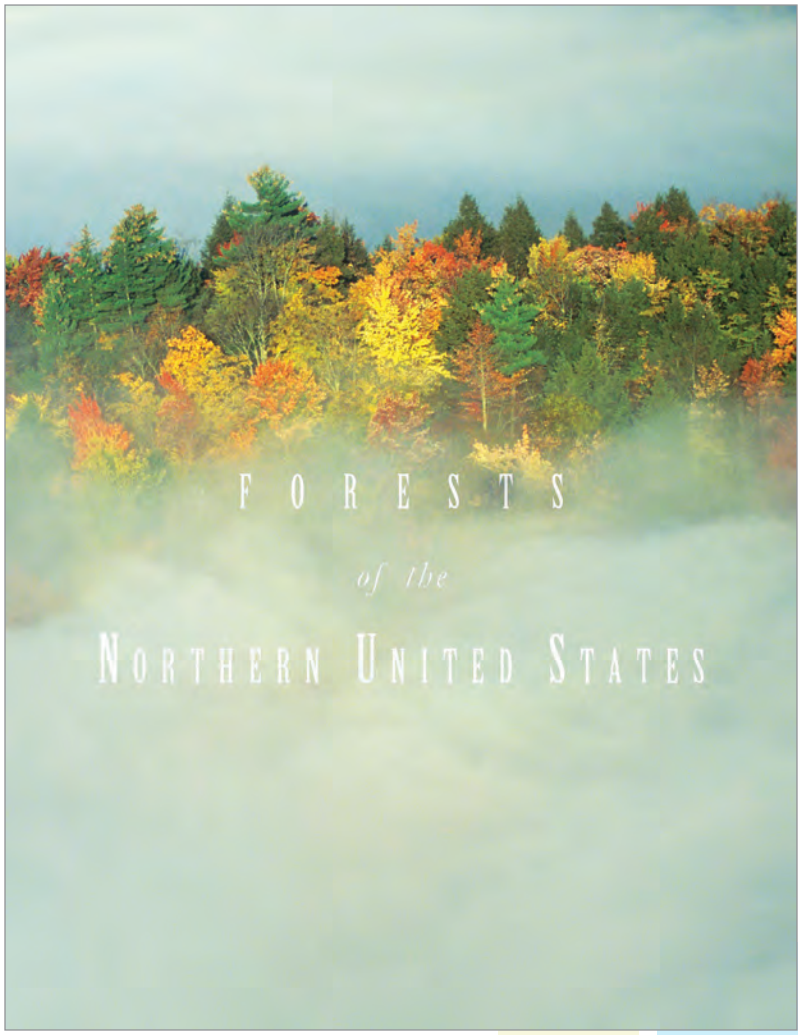
Lead: Northern Research Station

Report Details Trends and Current Conditions for Northern Forests

Overarching issues include the interaction of forests and people, managing invasive species, sustaining biodiversity, and sustaining capacity for forest management

"Forests of the Northern United States" provides a detailed portrait of recent trends and current conditions for the 20 Northern States bounded by Maine, Maryland, Missouri, and Minnesota. Details for individual Northern States are included in more than 100 maps, graphs, and tables and via online data exploration tools. Overarching issues identified for northern forests include understanding the interaction of forests and people, managing invasive species, sustaining biodiversity, and sustaining the capacity for forest management. This assessment of the Nation's most densely forested and most densely populated quadrant presents conditions in terms of eight dimensions or criteria related to sustainable forests. The first seven criteria follow the outline of the Montréal Process Criteria and Indicators: biodiversity, productive capacity, health, soil and water resources, carbon and biomass, socioeconomic benefits, and legal and institutional framework for conservation. The eighth criterion addresses the North's urban and community forests that occur in close proximity to more than 80 percent of the region's population.

Report cover. *Forest Service*

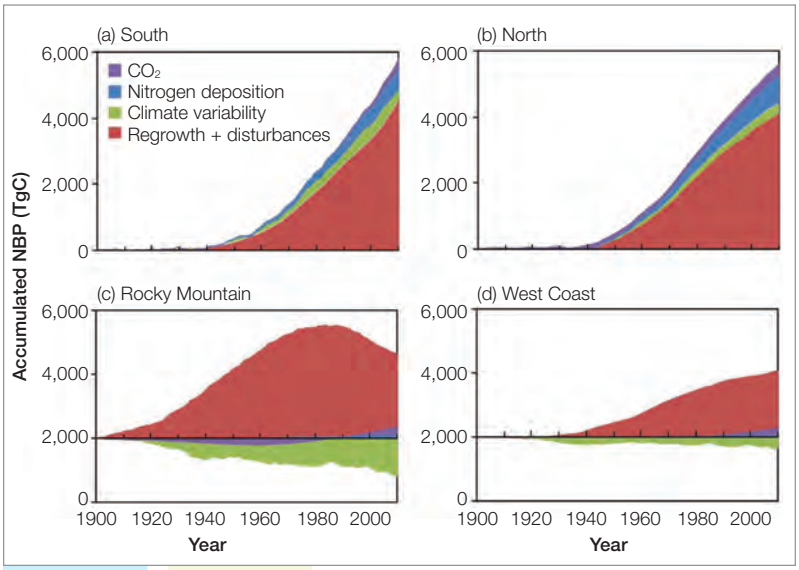


Lead: Northern Research Station

Effects of Disturbance, Climate, and Management on U.S. Forest Carbon

Forest response to fire, insects, harvesting, etc., is responsible for nearly one-half of the U.S. forest carbon sink, offsetting about 12 percent of U.S. fossil fuel emissions

Forest Service scientists combined an advanced ecosystem process model with data from Forest Inventory and Analysis and remote sensing to separate the effects of disturbance factors (harvesting, fire, and insects) from nondisturbance factors (climate variability, carbon dioxide fertilization, and nitrogen deposition). Results showed that disturbance factors had the strongest effects overall, but with significant regional and temporal differences. This is the first instance in which separation of causes has been possible at the continental scale, and this new information can be used to support development of policies and approaches to improve sustainable forest management and provide for cleaner air and water. Recent climate variability (increasing temperature and droughts) and atmospheric composition changes (nitrogen deposition, rising carbon dioxide concentration) along with harvesting, wildfires, and insect infestations, have had significant effects on U.S. forest carbon uptake. The carbon changes in forests of the conterminous United States can be attributed to disturbance and nondisturbance factors. Factors were grouped into disturbances (harvesting, fire, insect infestation) and nondisturbances (carbon dioxide concentration, nitrogen deposition, and climate variability), and their subsequent effects on forest regrowth patterns were estimated. Results showed that, on average, the carbon sink in the conterminous U.S. forests from 1950 to 2010 was 87 percent of the sink in living biomass. Compared with the simulation of all factors combined, disturbance factors alone (including forest regrowth after disturbances) may contribute 46 percent of the sink, while nondisturbance factors alone contribute about 24 percent of the sink. The study also showed diverse regional patterns of carbon sinks related to the importance of driving factors. From 1980 through 2010, disturbance effects dominated the carbon changes in the South and Rocky Mountain regions, were nearly equal to nondisturbance effects in the North, and had minor effects compared with nondisturbance effects in the west coast region.



Contributions of elevated carbon dioxide concentration, nitrogen deposition, climate variability, and regrowth plus disturbances to regional accumulated net biome productivity (NBP). *Forest Service*

Lead: Northern Research Station

Blight-Resistant Seeds May Be Key to Comeback for American Chestnut Tree

Restoration plantings poise this once mighty tree species for a comeback

The American Chestnut Foundation (TACF) provided the most blight-resistant seed from its breeding program, and these plantings represent an important next step to test blight resistance in the field and to understand the ecological steps necessary for successful American chestnut restoration. The American chestnut was the dominant tree species in the Appalachian Mountains before an introduced fungus significantly reduced its population and changed the way of life for early human inhabitants who relied on this tree for food, shelter, and animal production. The Northern Research Station's Hardwood Tree Improvement and Regeneration Center (HTIRC) and TACF have begun two restoration plantings on the Wayne and Hoosier National Forests. National forest staff provided the land, site preparation, and field crews; TACF provided the seed; Indiana State Nursery at Vallonia provided the nursery culture; HTIRC staff from the Forest Service, Purdue University, and the Indiana Chapter of TACF helped to coordinate and plant the initial restoration sites in the Midwest. If successful, these plantings will lead to reintroduction of an iconic eastern forest tree species that existed before an exotic pathogen nearly extirpated it.

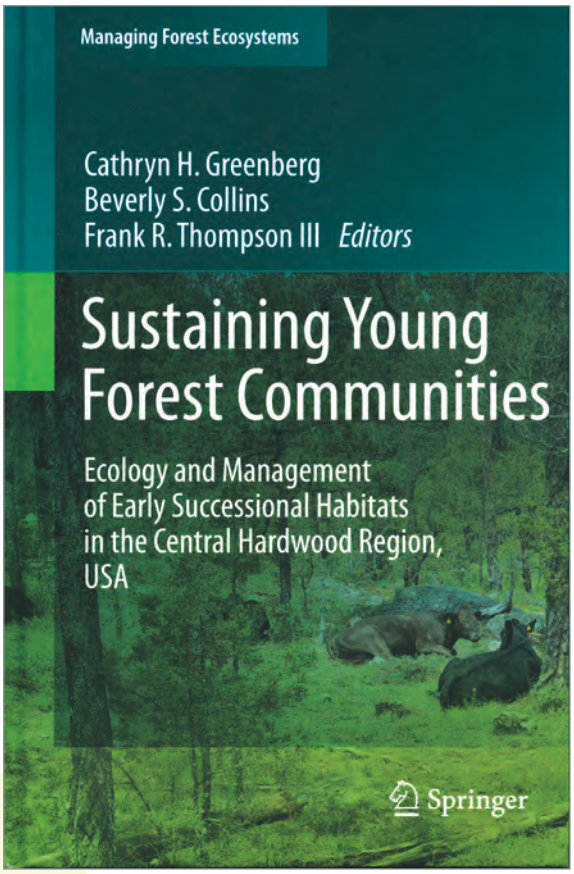
Establishing a blight-resistant planting at Buck Creek on the Hoosier National Forest in spring 2012. *Forest Service*

Lead: Northern Research Station

Research Addresses Decline of Young Forests in Central Hardwood Region

Report details how young forests can be sustainably created and managed in a landscape context

Early successional habitats, which grow after natural and human disturbances, are declining in the central hardwood region. Natural resource scientists and managers are increasingly concerned about the many plant and animal species living in these habitats. Forest Service scientists have summarized decades of research on management for early successional habitats and the tradeoffs among ecological services such as carbon sequestration, hydrologic processes, forest products, and biotic diversity between young, early successional habitats and mature forest. Forest Service scientists have spent decades studying the critical topic of how the habitats can be sustainably created and managed in a landscape context. This work was recently summarized in volume 21 in the Managing Forest Ecosystems series, titled "Sustaining Young Forest Communities," which was coedited by a Forest Service scientist. The balanced view of past, current, and future scenarios on the extent and quality of early successional habitats within the central hardwood region and implications for ecosystem services and disturbance-dependent plants and animals should be of great value to land managers and others concerned with these habitats.



Book cover. *Forest Service*

Lead: Northern Research Station

Repeated Prescribed Fires Help Sustain Oak Regeneration in Eastern Forests

Research findings can help managers in their quest to sustain this forest type throughout Eastern North America

The oak regeneration problem is one of the most important forest management issues today in the Eastern United States as many wildlife species are dependent on acorns. A Forest Service study has shown that repeated prescribed fires may improve the regeneration potential of oak in canopy gaps. These findings can help managers in their quest to sustain this forest type throughout Eastern North America. Oak dominance is declining in eastern forests, as canopy oaks that die or are harvested are often being replaced by other tree species, to the detriment of the many wildlife species that depend on acorns. Evidence of historic fires in oak woodlands and forests has led to the use of prescribed fire as a tool to improve oak regeneration. Forest Service scientists studied the effects of repeated fires during a 13-year period in the Vinton Furnace State Experimental Forest in southern Ohio. Prescribed fires applied three to five times in experimental units reduced the density of small, nonoak trees but had little effect on larger overstory trees. In year 8, natural canopy gaps formed during a regional white oak decline. In these gaps, tree regeneration was strikingly different in burned and unburned gaps. Unburned gaps were being filled in by shade-tolerant saplings, such as red maple and beech, and oak seedlings remained small. In burned gaps, fires had eliminated most of the tolerant saplings, allowing a greater amount of light to illuminate the forest floor, facilitating the development of larger and more competitive oak seedlings. Thus, multiple prescribed fires followed by the creation of canopy openings may considerably improve the sustainability of oak forests.

Repeated prescribed fires may improve the regeneration potential of oak in canopy gaps. *Forest Service*

Lead: Northern Research Station

Scientists and Managers Work To Develop "Climate-Smart" Conservation Strategies

Project that addresses the needs of land managers in a changing climate has expanded to nine States and more than 133 million acres

Climate change has the potential to have long-term effects on forest ecosystems and the services that they provide. The Climate Change Response Framework, developed by Forest Service scientists and a network of partners, is an integrated set of tools, partnerships, and actions to support climate-smart conservation and forest management. During the past year, the framework has expanded its coverage from northern Wisconsin to three large ecoregions across the Eastern United States: the Northwoods, the Central Hardwoods, and the Central Appalachians. These framework projects cover more than 133 million acres, spanning 9 States and including 11 national forests. The diversity of partnerships continues to grow, with more than 45 current active partners among State, Federal, tribal, nongovernmental groups, and industry groups and organizations. Scientists and managers from a variety of organizations taking part in multiple workshops initiated and informed five ecosystem vulnerability assessments and several adaptation demonstration projects. The information and partnerships developed at framework workshops will be used to create additional resources that will help land managers respond to changing forest conditions.

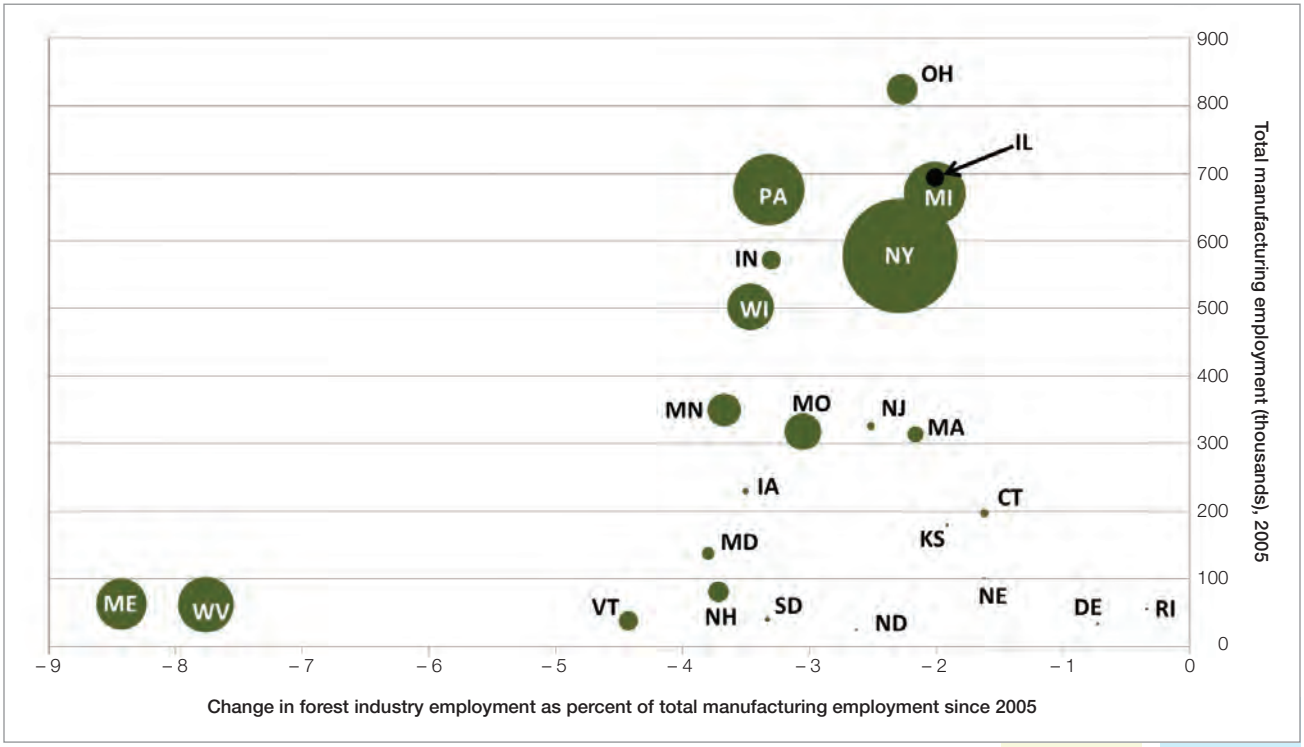
Lead: Northern Research Station

Analysis Reveals Cyclical and Structural Changes in Forest Products Industry

Structural changes may be difficult to reverse, but prospects for growth exist in forest product exports and wood-based biorefining

In recent years, the forest products sector in the United States experienced a downturn in output to levels not seen in decades and experienced job losses in the hundreds of thousands in the forestry and related sectors of the economy. The pattern of the downturn varies by industry, as affected by structural changes in the overall economy. Globalization of manufacturing and expanded use of electronic media contributed to a decline in U.S. pulp, paper, and paperboard output since the late 1990s, while the collapse of housing construction since 2005 and offshore manufacturing of furniture production contributed to declines in U.S. wood product output. The more recent global economic recession of 2007 through 2009 accentuated the downturn. Forest Service researchers analyzed the downturn, focusing on trends in forest-sector economic activity and employment. Their analysis points to structural changes that may be difficult to reverse, but also finds some prospects for growth in the future, including increased forest product exports and wood-based biorefining.

The change in forest industry employment from 2005 to 2010 compared to each State's total manufacturing employment in 2005. Each State's circle is scaled to its total timber land growing stock volume in 2010 (northern region). *Forest Service*



Lead: Northern Research Station

Effect of Woody Biomass Removal on Forest Biodiversity and Nutrient Cycling

Findings represent short-term effects and give baseline for long-term study

National forests are facing increasing pressures to allow woody biomass harvesting to help meet the Nation's demand for alternative energy sources, but the short- and long-term effects of such removals are unknown. A readily available source of biomass material is the slash from forest thinning operations that are traditionally left on the forest floor. This woody debris is a critical element in managing biodiversity and nutrient cycling. Forest Service scientists examined the effects of removing different intensities of fine woody debris (tops and limbs) at 2 years after harvest in a northern hardwood system. One of the removal intensities was a current recommended best management practice. The scientists studied community assemblages of amphibians, herbaceous plants, and beetles and nutrient cycling. In general, few short-term qualitative changes in species composition existed at the plot-level across the three debris removal treatments sites for all species groups. Tree regeneration was similar across treatments. These findings represent short-term responses of multiple trophic levels to forest residue removal and provide baseline information to begin evaluating long-term effects of woody biomass removal on forest biodiversity and nutrient cycling.

Fine woody biomass (tops and limbs) of northern hardwoods are removed post-harvest and stacked for processing, Chequemegon-Nicolet National Forest, Wisconsin. *Forest Service*

Lead: Northern Research Station

Effects of Timber Harvesting and Biomass Removal on Forest Health Studied

A 10-year study shows that forest sites are able to experience high levels of soil compaction and biomass removal with little negative effects on seedling growth and nutrition

Questions relating to how harvesting intensity and biomass removals affect the long-term ability of sites to sustain forest productivity is being studied across North America by a network of Forest Service scientists and their collaborators. This 10-year assessment of harvest effects shows that forest sites are able to experience high levels of soil compaction and biomass removal with little negative effects on seedling growth and nutrition. The North American Long-Term Soil Productivity (LTSP) Program was begun in the mid-1990s to quantify the short- and long-term effects of different intensities of timber harvesting and biomass removal on soil productivity at 29 different study sites located throughout North America, including the Missouri Carr Creek. Recent examination of aboveground growth of planted trees and their foliar nitrogen and phosphorus concentrations showed that regional and transcontinental changes in planted tree biomass or foliar nutrition were neutral or positive with increasing intensity of harvesting disturbance and organic matter removal for most species after 10 years. Whole-tree harvesting or whole-tree plus forest-floor removal did not consistently reduce tree growth or foliar nutrients compared to stem-only harvest. Soil compaction, including severe, consistently increased planted tree biomass at all study sites, if the forest floor was left intact. Vegetation control with herbicides consistently enhanced tree growth across all study sites and increased foliar nitrogen and phosphorus of pine and oak species. Overall, harvest-related organic matter removal and soil compaction did not result in large losses in stand biomass 10 years after harvesting, except for in aspen stands.

Felix Ponder standing at one of his Long-Term Soil Productivity sites. *Forest Service*

Lead: Northern Research Station

New Management Guide Offers Strategies for Northern White-Cedar

Guide contains newly discovered and proven management strategies for one of the least-studied commercially important North American tree species

Northern white-cedar is an important tree species throughout the Northeastern United States and adjacent areas of Canada, occurring in pure stands and as a minor species in mixed stands of hardwoods and other softwoods. Northern white-cedar has important commodity and noncommodity values—it is a source of niche products, such as shingles and fence posts, and it is a sacred plant for Native Americans. It also contributes to biodiversity by increasing local tree species richness and providing wildlife habitat. Foresters, however, have little information about its characteristics and potential, and as it is often a minor component of mixed-species stands, it is harvested opportunistically during operations aimed at more abundant species. This inattention to white-cedar silviculture has had negative effects; the species has become less dominant within mixed-species stands, and fewer of these cedar stands exist overall. To remedy this problem, Forest Service scientists and partners conducted more than a decade of research. Their work includes a synthesis of knowledge and new studies of white-cedar regeneration, growth, mortality, site relationships, and responses to treatment. Their recommendations include retaining and releasing cedar in managed stands and establishing and protecting advanced regeneration and residual trees during harvesting. In mixed-species stands, where more abundant species are driving prescriptions, the management plan suggests an innovative microstand approach in which pockets of white-cedar are identified and managed. The "Silvicultural Guide for Northern White-Cedar (Eastern White-Cedar)" has been published in English and French by the United States and Canadian Forest Services.

White cedar browsed by deer.
Forest Service

Lead: Northern Research Station

Biomass Potential of Poplar Energy Crops in Minnesota and Wisconsin Assessed

Scientists develop methods to map sites for poplar tree energy crops to enhance productivity and ecosystem services

Short-rotation woody crops such as poplar trees and poplar-hybrid varieties are a significant component of the total biofuel and bioenergy feedstock resource in the United States. Production of these dedicated energy crops can result in large-scale land conversion, raising questions about the economic, logistic, and ecologic feasibility of the crops. To address such concerns, Forest Service scientists used available social (i.e., land ownership and cover) and biophysical (i.e., climate, soil characteristics) spatial data to map eligible lands suitable for establishing and growing poplar biomass for bioenergy crops across Minnesota and Wisconsin. They confirmed the validity of this mapping technique by sampling and assessing biotic variables within locations identified on the maps. In addition, they estimated potential poplar productivity within identified areas using a process-based growth model to determine spatial distribution of productive lands across the study area. Although this novel approach was validated for Minnesota and Wisconsin, the methodology is useful across a wide range of geographic conditions, irrespective of intraregional variability in site and climate parameters. Thus, this information is vital for siting poplar energy production systems to increase productivity and associated ecosystem services and is widely applicable to woody biomass production systems worldwide.

Industrial poplar farm. *Forest Service*

Lead: Northern Research Station

Guidelines Presented for Forest Biomass Utilization

Online resource offers environmentally and economically sound biomass utilization in the Appalachian Mountains

Forest biomass is an increasingly important resource for renewable energy in the Appalachian Mountains. Understanding the potential effects on ecosystem productivity is necessary for researchers and policymakers to develop guidelines for sustainable development of this resource. Forest Service scientists and cooperators have synthesized and published existing data and information and made it available with an online bibliography. Increased demand for woody biomass in the forest-rich Appalachian Mountain region can be met, at least in part, by improved use of forest resources. Relatively little research has evaluated the effects of such forest biomass harvesting on site productivity, biodiversity, water quality, and other measures of ecosystem productivity, and new information about these and other related topics is not readily available. The implications for the sustainability of Appalachian hardwood forests from additional woody biomass removal for the production of woody biomass-related energy were assessed, and the possible effects on site productivity, water quality, wildlife, biodiversity, and wood supply were evaluated. The Forest Service scientists and partners have synthesized published literature and ongoing studies to develop management guidelines for minimizing the effects of woody biomass utilization on the sustainability of Appalachian hardwood forests.

How much forest biomass to leave behind or remove? *Shawn Grushesky, West Virginia University Appalachian Hardwood Center*

Lead: Northern Research Station

Feedback Through the Land Market Affects Success of Open Space Conservation Policy

A new planning tool helps decide which land parcels to save

Nationwide, conservation organizations acquire sites to protect open space and wildlife habitat within or on the fringe of metropolitan areas. A Forest Service scientist has developed a planning tool to help organizations prioritize areas for open space conservation where development pressure is high and land conservation can have the unintended consequence of increasing land price, promoting development, and limiting future conservation options. More than 80 percent of the U.S. population lives in urban areas, which are experiencing rapid growth and large-scale conversion of open space to development. Citizens are concerned about the resulting loss of open space. In response, local organizations have policies and funds to acquire land within or on the fringe of metropolitan areas. A fundamental question is how to prioritize site selections given finite budgets: should funds be spent on small, expensive parcels under high risk of development, or on larger, inexpensive parcels that are further away from population centers? A Forest Service scientist developed a conservation planning tool that incorporates the effect of site selection decisions on land price and development. The tool helped prioritize land conservation decisions at Lopez Island, WA, which is close to Seattle, WA. The island supports many unique and sensitive wildlife species and habitats, but is under pressure for development. Results using the tool suggest that, on Lopez Island, it is better for conservationists to acquire small, expensive, parcels that have high conservation value and high risk of development. This approach limits the risk of unintentional increases in land price and development in the surrounding area and increases options for future open space conservation.

Lead: Northern Research Station

Nature Dominates in City Tree Regeneration

Assessment of tree planting and natural regeneration in cities reveals that most trees in cities are not planted

Although humans may think they dominate the city environment, nature plays a significant role in affecting tree species composition and tree cover in cities. Forest Service scientists used field data from 12 cities in the United States and Canada to estimate the proportion of the existing tree population that was planted or regenerated naturally on a given site. On average, humans plant about one in three city trees. Natural regeneration in cities can be dominated by exotic invasive species, which will change the forest composition over time. The study found the percentage of trees planted by humans varied with land use (residential land has with the highest proportion of trees planted), species (the most commonly planted was honeylocust), and the natural environment (cities developed in grassland areas have a greater proportion of trees planted than cities developed in forests). Percent of tree population planted by humans also increases with population density and impervious cover in cities. New tree influx rates ranged from 1.6 trees per acre per year in Baltimore, MD, to 3.5 trees in Syracuse, NY. In Syracuse, the recent tree influx has been dominated by European buckthorn, an exotic invasive species. Without tree planting and management, the urban forest composition in some cities will likely shift to more pioneer or invasive tree species. Because these species are typically smaller and have shorter life spans, the ability of city systems to sustain larger, long-lived tree species may require human intervention. These data on tree regeneration and planting proportions and rates can be used to determine tree planting rates necessary to attain desired tree cover and species composition goals.

Infestation of European buckthorn (Rhamnus cathartica L.) on left with bush honeysuckle on right. *Chris Evans, River to River Cooperative Weed Management Area, http://bugwood.org*

Lead: Northern Research Station

Can We "Bank" on Forest Seed Banks?

Community composition of seeds stored in forest soils becomes increasingly divergent over time

Forest Service scientists used a 63-year chronosequence of forest stands that are distributed throughout northern Pennsylvania to assess variability in seed bank richness and abundance. Unlike prior seed bank studies, the sampling design and analyses that were used enabled scientists to test not only variability over time, but also variability within and among sites of different age classes (e.g., young versus old stands). This work corroborates prior work that documented diminishing seed bank richness and abundance over time and delivers the novel finding that even across sites experiencing similar histories, seed bank composition grows increasingly dissimilar and less predictable as sites age. Seed banks—viable seeds buried in soil—serve as taxonomic and genetic diversity reservoirs buffering plant populations from disturbance. Existing studies show that differential seed longevities govern seed bank diversity; seeds of most species survive up to a few years while others persist for decades. Nevertheless, we lack a general understanding of how seed bank diversity varies across space and time. Elucidating spatiotemporal variation in seed bank composition is vital to forest renewal after disturbance. In 39 forest stands, aged 43 to 106 years post-disturbance, which are distributed across northern Pennsylvania, Forest Service scientists found that seed bank richness and abundance steadily declined beginning about age 50, with sites 95 years old or older characterized by species with long-lived seeds. Composition at older sites was nevertheless considerable, with older sites being dissimilar from younger sites and each other. These results suggest that despite strong effects of differential seed longevities, intersite seed colonization, and extinction-event variation ultimately yields strikingly different communities. This work provides forest managers important information for maintaining diverse forests as it demonstrates that banking on recovery from seed banks may be challenging, because outcomes are unpredictable and difficult to manage.

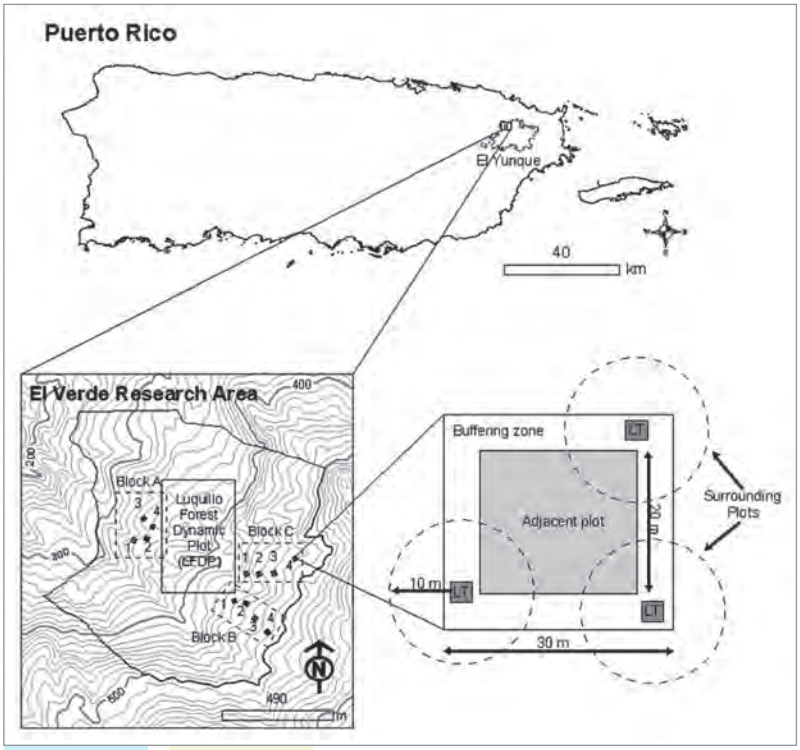
Greenhouse seed bank germination trials with closeup of one tray. *Forest Service*

Lead: Northern Research Station

Assessing Litterfall Trap Bias

Are traps preferentially representing certain kinds of leaf litter?

Forest Service scientists determined several factors that may cause bias while sampling litterfall in a forest, leading to over- or under-representation of the species present in the surrounding vegetation. Before this study, the few studies dealing with patterns of litterfall dispersal and collection provided contradictory results, so Forest Service scientists examined the correspondence between litterfall samples and standing vegetation in the Luquillo Experimental Forest in Puerto Rico. The scientists compared litterfall and standing vegetation in a subtropical wet forest in Puerto Rico at three spatial scales—forest, sampling blocks, and plots—to determine the effect of tree height, crown area, leaf size, and distance to traps on litterfall species composition; to determine if representativeness of litterfall samples was affected by litter traps' central or lateral location relative to vegetation plots; and to gain insights on scaling up data of litterfall from sampling plots into forest-stand scale. Higher tree height and a wider crown were more important in determining the relative abundance of species in litterfall samples than trees at a closer location to litter traps. Central and lateral traps provided equally representative samples at the forest scale. Correlations between litterfall and plant species' relative abundances at the scale of plots showed that central traps better represented the surrounding vegetation than lateral traps. When comparing vegetation community with litterfall across scales, similarity decreased from the scale of forest to that of plots. Leaf size had a slight effect on litterfall composition suggesting that big and heavy leaves could be under-represented in litterfall samples. Due to the wide range of horizontal mobility of leaf litter, traps were not necessarily collecting leaf litter from the immediate vicinity. Therefore, care should be taken when scaling up from small to intermediate sampling units.



Block and plot structure in El Verde research area. Inferred area covered by each block is 40,000 square meters, and the complete study area covers around 106 square meters. *Forest Service*

Lead: International Institute of Tropical Forestry

Forest Regulations Are Rigorous Throughout Much of the Americas, but Implementation Remains a Challenge in Latin America

On paper, Latin America is often stricter on forestry than many States in the United States, but lack of enforcement and compliance continue to be a challenge

Although forestry rules and regulations for private land are often stricter and more comprehensive in Central and South America than in the United States, poor implementation in many cases makes them ineffective and underscores the need for better enforcement and incentives. Since the first Earth Summit in 1991, most countries in the Americas have revised their forest laws and regulations significantly to achieve sustainable forest management. Forest Service scientists wanted to know more about the intended and actual effects of these laws on forest sustainability and how they compare among countries. This has not been studied extensively, but is crucial to the effective design and implementation of good forest governance. A group of forest policy scientists from throughout the Americas and the Forest Service conducted a study that examined key components of natural forest management and how they are addressed through legislation and other policy directives in Argentina, Brazil, Chile, Costa Rica, Guatemala, Nicaragua, Paraguay, Uruguay, and the United States. They found that, on paper, Latin America has more rigorous and comprehensive (i.e., stricter thresholds on more environmental, economic, and social aspects) forestry rules for private land than much of the United States. Overall, the protection of at-risk species and riparian buffers are required in all countries and include specific prescriptions in most; forest management planning and secure, legal land title or tenancy are commonly required; and mandatory processes to protect soil and water quality are customary. Less common requirements include forest monitoring, social and economic aspects; when in place, they are usually voluntary. Although a significant degree of rigor and comprehensiveness exists in forestry rules from Latin America, significant gaps between rules on paper and rules complied with persist. Significant efforts have been made to improve governmental forest regulation and to increase the transparency and legality of timber production and commerce in the tropics. However, competing land uses, unclear tenure, and limited institutional capacity for effective implementation and enforcement of forest legislation continue to be significant challenges for advancing the sustainability of forest management in many Latin American countries. Ultimately, the researchers stress that it is not the number, rigor, or comprehensiveness of rules and regulations related to forest sustainability that matter as much as the implementation and application of sound practices on the ground. These factors ultimately depend on the appropriate mix and balance of mandatory requirements for sustainable forest management, voluntary guidelines, information, education, and laissez faire.

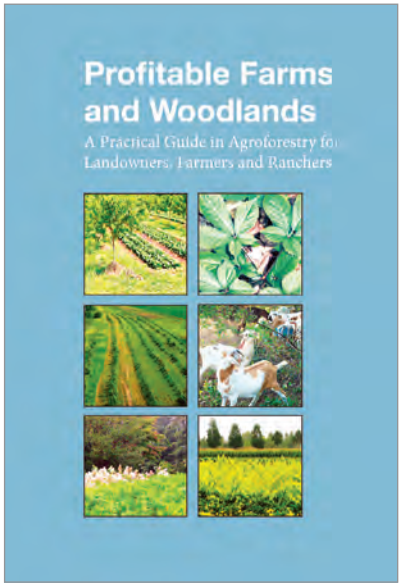
Reviewing compliance of harvest plans in the Consorcio Forestal Amazonico, Ucayali, Peru. *Forest Service*

Lead: International Institute of Tropical Forestry

Practical Agroforestry Guide Released for Landowners, Farmers, and Ranchers

Guide informs underserved and limited-resource farmers in the Southeast about ways to use agroforestry to better manage their lands and boost profits

In 2012, the Forest Service published a much-needed practical guide about agroforestry and distributed it to extension and other natural resource professionals in the Southeastern United States. Agroforestry is a unique land management approach for farms, ranches, and woodlands that intentionally combines agriculture and forestry to create integrated and sustainable land-use systems. "Profitable Farms and Woodlands," the first-of-its-kind handbook, was written specifically for minority landowners and agricultural producers living in the Southeastern United States. It includes chapters for each of the five main agroforestry practices: alley cropping, forest farming, riparian buffer strips, silvopasture, and windbreaks. The guide was developed by a team of agroforestry specialists from the 1890 and 1862 land-grant universities, led by the 1890 Agroforestry Consortium in close cooperation with the USDA's National Agroforestry Center (NAC) The guide depicts step-by-step methods and principles on developing agroforestry practices for the purpose of enhancing the economic and environmental benefits of their farms, ranches, and woodlands. Among the information in the book are simple explanations of how growing medicinal plants or mushrooms or cultivating bee products can help landowners join a multibillion-dollar industry. Limited-resource farmers and woodland owners who met twice in focus groups in Birmingham, AL, and Atlanta, GA, with a team of agroforestry experts suggested the contents of "Profitable Farms and Woodlands." The views expressed by these underserved and limited-resource landowners were the guiding light that led to the publication's development. NAC facilitated intensive reviews of each chapter and contracted with *Minority Landowner* magazine for the final editing to ensure the information applied to the targeted audiences and their needs. Copies of "Profitable Farms and Woodlands" are available as a take-home resource for participants from NAC for organizations that sponsor agroforestry-related workshops. The guide can be viewed or downloaded at http://nac.unl.edu/documents/morepublications/profitable_farms.pdf.



Report cover. *Forest Service*

Lead: USDA National Agroforestry Center, a unique partnership between two arms of the Forest Service, Research & Development and State & Private Forestry (Washington Office), and the USDA Natural Resources Conservation Service.

The United States Partners With Canada To Increase the Use of Agroforestry Practices

Partnership actions include collaborative research to restore windbreaks across the Great Plains and advancing the goals of the Global Research Alliance on Agricultural Greenhouse Gases

In 2012, U.S. Department of Agriculture (USDA) Secretary Tom Vilsack announced a cooperative partnership between the USDA and Agriculture and Agri-Food Canada to promote agroforestry practices to help landowners improve water quality, control soil erosion, and boost their agriculture production. The memorandum of understanding establishing the cooperative partnership allows USDA's National Agroforestry Center in Lincoln, NE—jointly sponsored by the Forest Service and the USDA Natural Resources Conservation Service—and Canada's Agri-Environment Service Branch's Agroforestry Development Centre in Indian Head, Saskatchewan, to collaborate on research and development, including the advancement of agroforestry science and tools for climate change mitigation and adaptation in temperate North America. The two centers will also support the goals of the Global Research Alliance on Agriculture Greenhouse Gases, of which both countries are members. Information will be shared with landowners, managers, and natural resource professionals. "Canada and the United States have a strong relationship with regards to many aspects of the agricultural sector," said Canada's Agriculture Minister Gerry Ritz. "I'm pleased that we can now add agroforestry to that growing list, as agroforestry is an area that is not only good for the environment, but also for our farmers' bottom lines." Deputy Secretary Kathleen Merrigan signed the agreement on behalf of USDA and Deputy Minister John Knubley signed the agreement on behalf of Agriculture and Agri-Food Canada.

Kathleen Merrigan (left), U.S. Department of Agriculture Deputy Secretary, and John Knubely (right), Deputy Minister, Canada Agriculture and Agri-Food sign a Memorandum of Understanding verifying enhanced collaboration in agroforestry between the two nations at the U.S. Department of Agriculture, April 17, 2012, in Washington, DC. *Bob Nichols, U.S. Department of Agriculture*

Lead: USDA National Agroforestry Center, a unique partnership between two arms of the Forest Service, Research & Development and State & Private Forestry (Washington Office), and the USDA Natural Resources Conservation Service

Location, Location, Location! Putting Buffers in Their Place

Forest Service conservation buffer research highlighted at Capitol Hill seminars

U.S. Department of Agriculture (USDA), National Agroforestry Center Research Ecologist Mike Dosskey was the featured speaker on July 30, 2012, at two Capitol Hill seminars. Dosskey's presentation, Location, Location, Location! Putting Buffers in Their Place, featured a new Geographic Information System (GIS)-based targeting tool that shows where vegetative buffers should be located in agricultural landscapes to maximize retention of sediments, nutrients, and other water pollutants. Vegetative buffers are strips of grass and trees designed into agriculture landscapes to improve drinking water quality and aquatic health by trapping sediment and farm chemicals from runoff before they get into streams. Dosskey's research shows that fixed-width buffers along field margins and waterways are often not the best locations when protecting water quality is the primary goal. Realizing the potential for vegetative buffers to improve water quality requires that they be put in the right places. New planning tools that Dosskey and his cooperators at the University of Kentucky are developing will enable more precise discernment of pollutant sources, runoff pathways, and buffering capabilities across landscapes. The tools capitalize on GIS technology and the widespread availability of spatial data on land uses, stream networks, soil properties, and topography for identifying where the right combination of conditions exist to achieve disproportionately greater effect from vegetative buffers. The simplicity of the new tool will more effectively deliver conservation buffer assistance to landowners through USDA's Conservation Reserve and Environmental Quality Incentives programs. These programs have long employed a simple model of targeting downhill sides of agricultural fields and along stream courses. By guiding conservationists toward higher impact locations and away from less promising ones, the use of these new tools may substantially improve the cost-effectiveness of vegetative buffers and water quality improvement programs. About 90 people from congressional offices, nongovernmental organizations, and agribusiness attended the seminars.

The U.S. Department of Agriculture, Forest Service/National Agroforestry Center's Mike Dosskey presents his conservation buffer research results on Capitol Hill, July 30, 2012, at a seminar sponsored by the National Coalition for Food and Agricultural Research. *Forest Service*

Lead: USDA National Agroforestry Center, a unique partnership between two arms of the Forest Service, Research & Development and State & Private Forestry (Washington Office), and the USDA Natural Resources Conservation Service

Wood Can Last for Centuries if Protected From Moisture

Report dispels myths about wood construction through proper information that educates and empowers the public

Forest Service scientists dispel the myth that wood construction will not last as long or be as "green" as steel or concrete in a report that educates the public on home maintenance and empowers them to make an informed choice for their next construction project. With user-friendly information, homeowners can address many home maintenance issues before costly repairs. A new report, "Build Green: Wood Can Last for Centuries," illustrates many common moisture-related problems that can lead to decay if ignored and points out that with proper attention to detail, wood that is protected from moisture can last indefinitely. Wood as a construction material has seen fierce competition from alternative products, such as steel and concrete, under the auspice that wood will not last as long, and occasionally because of the misconception that steel and concrete are greener than wood. Nothing could be farther from the truth. As the United States is on the cusp of a green revolution, no time is better than now to promote wood in construction as a means to mitigate climate change and to highlight the environmental benefits of choosing wood for residential and nonresidential construction. Educating homeowners with common-sense maintenance advice gives them the tools they need to improve home comfort and durability and to influence their choice of building materials in future construction projects.

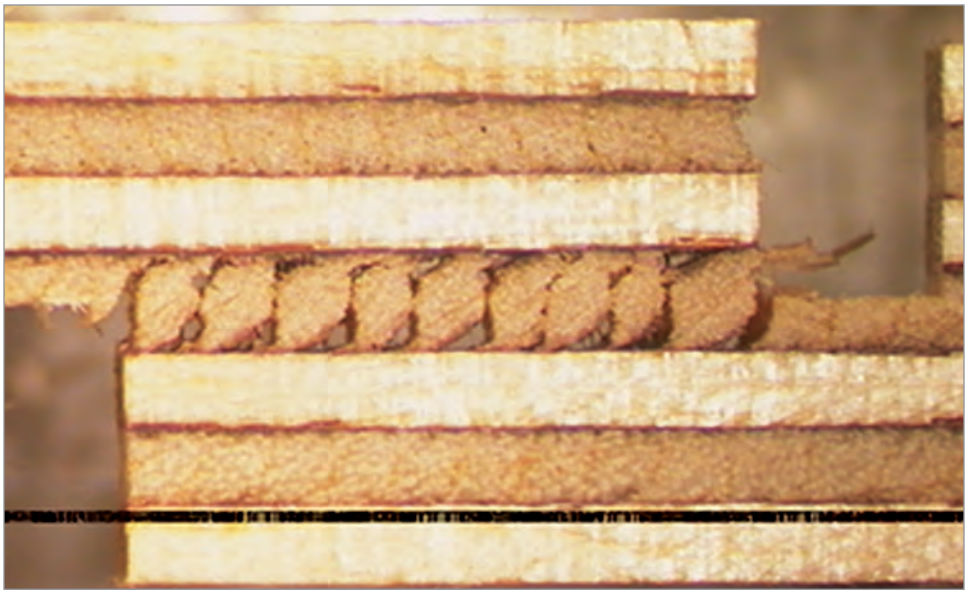
The Fairbanks House demonstrates design and construction details that have allowed this wood structure to stand for three centuries. *Jeffery Howe, Boston College*

Lead: Forest Products Laboratory

Adhesives Can Provide Quality in Making Plywood and Wood Flooring

Perfectly good adhesives may be wrongly discarded after failing a performance test when in actuality the veneer caused the failure.

Scientists have tested adhesive performance for making plywood and engineered wood flooring, assuming that smooth veneers of the same species were equal in properties. Work in Finland, however, in conjunction with the Forest Products Laboratory, has shown that this assumption is not correct. Therefore, perfectly good adhesives may be wrongly discarded after failing a performance test when in actuality the veneer caused the failure. Thin sheets of wood (veneers) are bonded together with adhesives to make plywood and engineered wood flooring. In tests for wood adhesive quality, one assumes that all smooth veneers of the same species produce products with similar strength. In a joint program between the Forest Products Laboratory and Aalto University (Espoo, Finland), scientists have shown that two factors (log soaking temperature and check depth) make this assumption false. Logs have traditionally been soaked in hot water first to make it easier to peel the veneer. Soaking logs in hot water was found to make a more bondable surface than soaking in room temperature water. Second, as the veneer is cut from the log, it develops checks (cracks) as it is bent going over the cutting knife. Deeper checks can give premature failure in the wood, resulting in low strength values. The result of this work is that we can prevent veneer failure from causing a perfectly satisfactory adhesive to fail the test. Not only should this work lead to a general improvement in veneer quality, but it can also educate the users by adding notes to some of the wood adhesive standards.



Adhesive test with low-quality veneer. *Forest Service*

Lead: Forest Products Laboratory

America's Iconic Covered Bridges Documented With "As Built" Records

Laser scanning technology provides details of historic covered timber bridges

Covered bridges are part of the fabric of American history, and several hundred historic covered bridges still exist today. Although much effort is expended to preserve these structures, the high cost of restoration, neglect, vandalism, and arson often take their toll, and many are lost forever. One of the more famous bridges featured in *Bridges of Madison County* burned in 2003, and Hurricane Irene destroyed a number of New England bridges in 2011. To prevent these types of incidents from occurring, the National Park Service's Historic American Engineering Record has efforts underway to document historic structures. To assist in this effort, researchers at the Forest Products Laboratory explored and developed laser scanning technologies that provide as-built records in an accurate, quick, and cost-effective manner. The Historic American Engineering Record Level I documentation is defined in the Secretary of the Interior's "Standards and Guidelines for Architectural and Engineering Documentation" and consists of measured and interpretive drawings, large-format photographs, and written historical reports. To assist in this effort, newer technologies need to be explored that can provide as-built records at a faster rate and with greater accuracy. This project highlighted the technical feasibility of using laser-scanning technologies to obtain as-built records for historic covered timber bridges.

Laser scanning technologies further preservation efforts of historic covered bridges. *Forest Service*

Lead: Forest Products Laboratory

Water Freezing in Wood: How Low Can It Go?

The freezing and melting of water in wood gives clues about how water bonds to wood during processes such as wood decay and fastener corrosion

Forest Service researchers examined the freezing and melting of water in solid wood and chemically isolated cell wall components. The melting temperature of the water depended on the wood's moisture content, and the behavior was similar between cell wall components. The data suggest water in wood may exhibit a "eutectic phase transformation" whereby a chemical composition solidifies at the lowest possible temperature. Traditional thinking suggests that wood holds water in one of two states: chemically bound to the cell wall or unbound in the cell lumina when the moisture content is above fiber saturation, or greater than 30 percent. These theories cannot account for the fact that several degradative processes in wood require water, such as mold growth and fastener corrosion, which begin at much lower moisture contents, between 15 and 20 percent. Recently, a third type of loosely bound water was reported in cellulose; this type of water was distinct in that it froze at a lower temperature than free water (some tightly bound water did not freeze). Using differential scanning calorimetry, Forest Service researchers explored the freezing and melting points of water in wood and chemically isolated wood components across a range of moisture contents. They found that freezing and melting temperatures of the water depended on moisture content and only observed the loosely bound water in cellulose when the material was ball-milled to a very small particle size. The results suggest that the so-called loosely bound water was actually an artifact of sample preparation. The dependence of freezing and melting temperatures on the moisture content suggests that thermodynamics of water in wood could be described by a eutectic phase transformation, which gives new insight into degradative processes in wood.

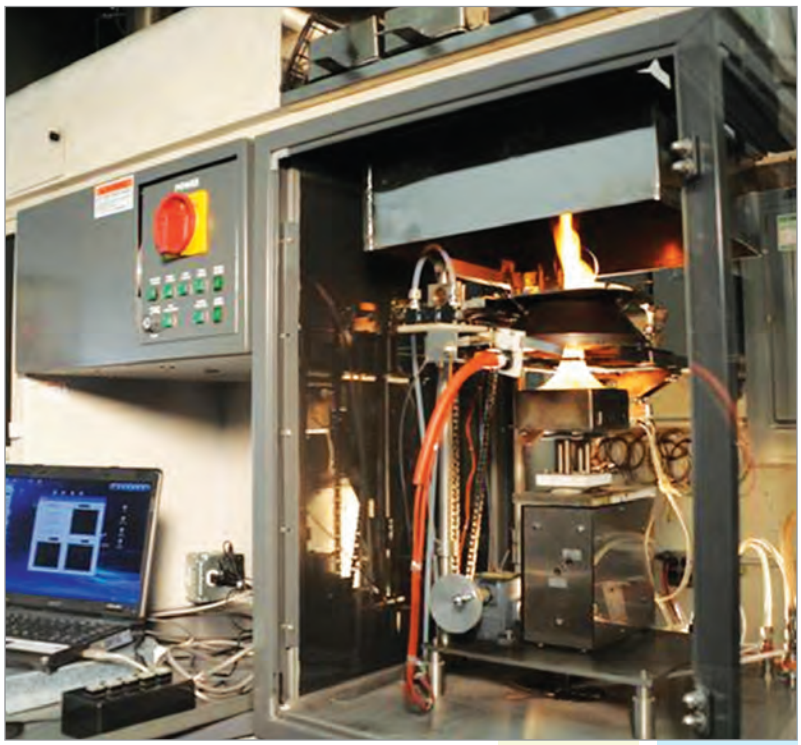
Researchers are studying the freezing and melting of water in solid wood to learn about wood decay and faster corrosion processes. *Tatiana* Morozova, http://www.shutterstock.com

Lead: Forest Products Laboratory

Cone Calorimetry Takes Center Stage in Evaluating Fire Retardancy of Wood Products

Evaluations of cone calorimeter tests are now documented in handbook

The cone calorimeter has become the preeminent fire test method for developing wood-based products since it was shown in 2002 to be applicable to combustion of wood volatiles and char in a realistic fire scenario of wood products treated with fire retardant. Researchers are using the equipment to evaluate the fire performance of wood products. The cone calorimeter has become the preeminent fire test method for developing wood-based products since it was shown in 2002 to be applicable to combustion of wood volatiles and char in a realistic fire scenario of fire retardant treated (FRT) wood products. Evaluations of cone calorimeter tests are now documented in Chapter 18: Fire Safety of Wood Construction of 2010 edition of "Wood Handbook: Wood as an Engineering Material" and Chapter 6: Thermal Properties, Combustion, and Fire Retardancy of Wood in the recently reissued "Handbook of Wood Chemistry and Wood Composites." For these handbooks, standard tests were adequate to determine the benefits of common FRT wood products, whereas innovative and nonstandard testing that involves hardware and gas analysis upgrades were needed for special fire retardancy situations. In the most recent study, conducted in collaboration with Hamburg University of Germany, a commercial FRT intumescent veneer adhered to both surfaces of an innovative foam core particleboard was found at to significantly reduce the heat-release-rate profile while exposed to 50 kilowatts per square meter irradiance with piloted ignition to predict a Class A fire performance. Advanced gas analysis, along with thermocouples embedded in various depths of the sample, was also used to explain how the improved fire performance was achieved.



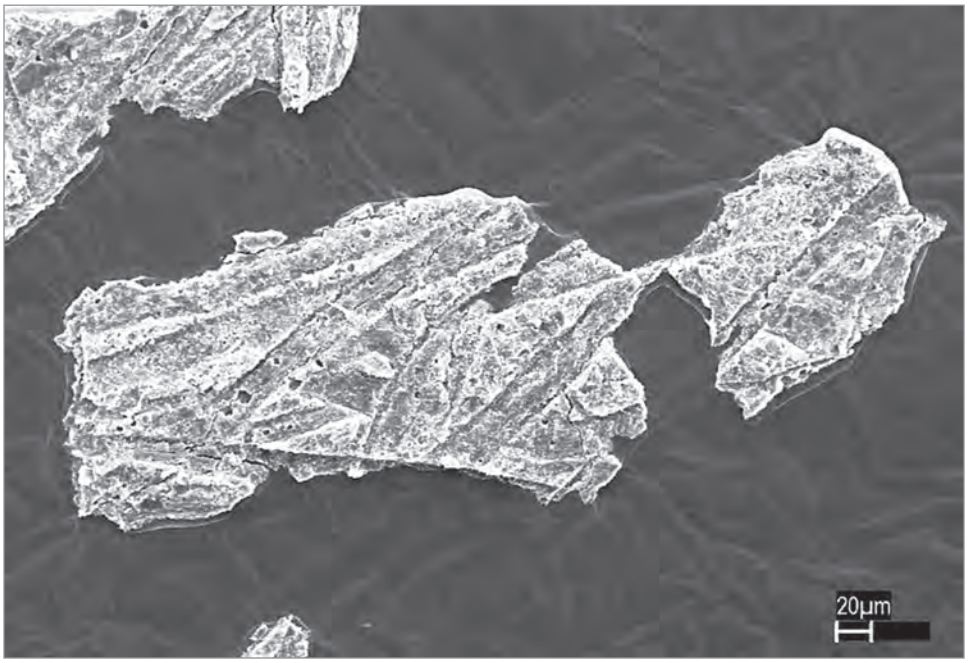
Cone calorimeter testing simulates realistic fire scenarios. *Forest Service*

Lead: Forest Products Laboratory

Forest Service Continues To Make a Better Postage Stamp

Latest research reduces the environmental effect of stamp materials

The U.S. Postal Service has sponsored cooperative research projects at the Forest Products Laboratory for more than 20 years. Initial research developed stamp adhesives that do not cause problems during paper recycling. More recently, the cooperation moved to accelerated aging tests for stamps and development of compostable adhesives. Researchers are developing improved performance and accelerated aging tests to assure that Forever Stamps are indeed useful—if not forever—at least close enough to qualify for the name. The electron micrograph shows a piece of the silicone-release liner stuck to a pressure sensitive adhesive (PSA) on the back of an experimental stamp that has been subjected to an accelerated aging process. Normally, the laminate separates between the silicone and adhesive, leaving a clean adhesive surface ready to attach to an envelope. The silicone contamination could ultimately cause the stamp to fall off during mail processing. Catching problems like this before stamps are released illustrates the importance of this research. In an effort to reduce the environmental effect of stamp materials, researchers are developing new PSAs that are produced from renewable materials and that will degrade in landfills. The current approach is to produce PSAs using pendent polylactic acid macromers attached to polymer backbones, which allows for biodegradation but still provides good performance. Beyond developing adhesives that may be used on future stamps and other commercial products, researchers are developing experimental methods for determining the biodegradation rate of new materials.



Electron micrograph image showing the unusual failure of release coating on a postage stamp. Dark regions are pressure-sensitive adhesive; light regions are silicone-release coating that has pulled away from backing paper liner. *Forest Service*

Lead: Forest Products Laboratory

New Drying Process Gives Black Locust Wood Exotic Appearance

Heat treatment that prevents discoloration increases uses of this fast growing wood

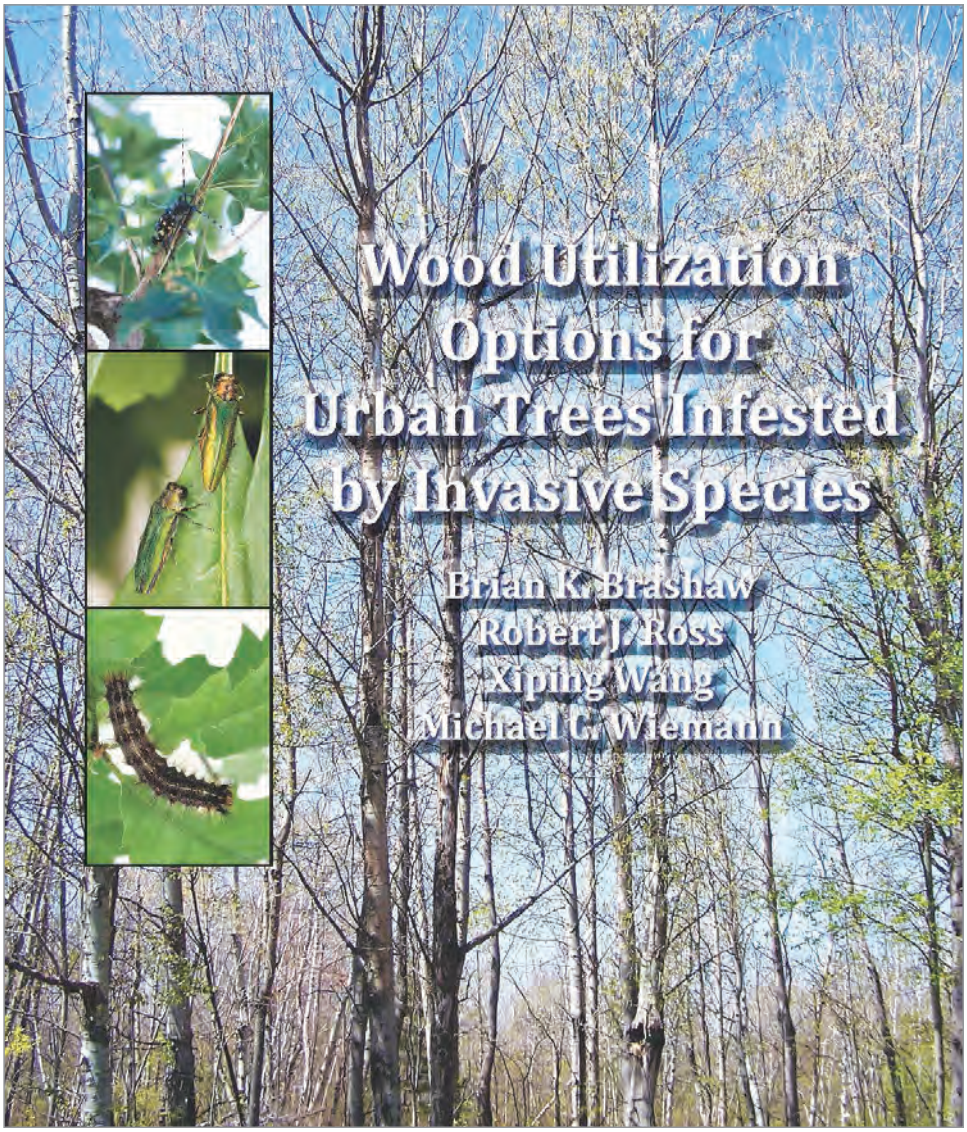
Black locust wood is a fast growing species with superior mechanical properties and is often used in making furniture. However, discoloration during drying often limits its application, necessitating a better understanding of heat treatment variables in order to enhance the black locust's wood color. Heat treatment creates the potential for black locust wood to resemble exotic hardwoods, thus increasing the use of this fast growing wood species and potentially decreasing demand for exotic foreign species. Forest Service scientists report that heat treatment variables can affect color changes in wood and color change is largely due to chemical structures within the wood. The first phase of this project investigated the effects of oxygen and moisture content on the chemical and color changes of black locust wood during heat treatment. Results indicate that oxygen (as an oxidation medium) plays an important role in the darkening of wood during heat treatment. Initial moisture content of 30 to 50 percent humidity appears sufficient to produce the darkening of the wood but higher moisture contents are required to produce sufficient darkening of the wood when exposed to nitrogen. The second phase included investigating the chemical and color changes at the polymer level within extractive-free black locust wood during heat treatment. Results suggest a range of alternative, suitable drying processes that can be used to produce black locust wood with a surface color closely resembling other desirable exotic hardwoods.

Lead: Forest Products Laboratory

Making the Most of Beetle-Killed Trees

New manual gives land managers a variety of options for beetle-killed trees

Forest Service researchers and their partners have developed a user-friendly guide that focuses on how best to use wood obtained from trees that were infected by invasive species, especially the emerald ash borer. "Assessing Wood Utilization Options for Urban Trees Infected by Invasive Species" is a comprehensive manual that can be used by professionals when assessing use options for bug-killed trees. The publication includes a summary of the technical viability of using these materials for value-added products in a variety of applications and will be useful to urban foresters, municipalities, and local industries looking for ways to use beetle-killed trees.



Report cover. *Forest Service*

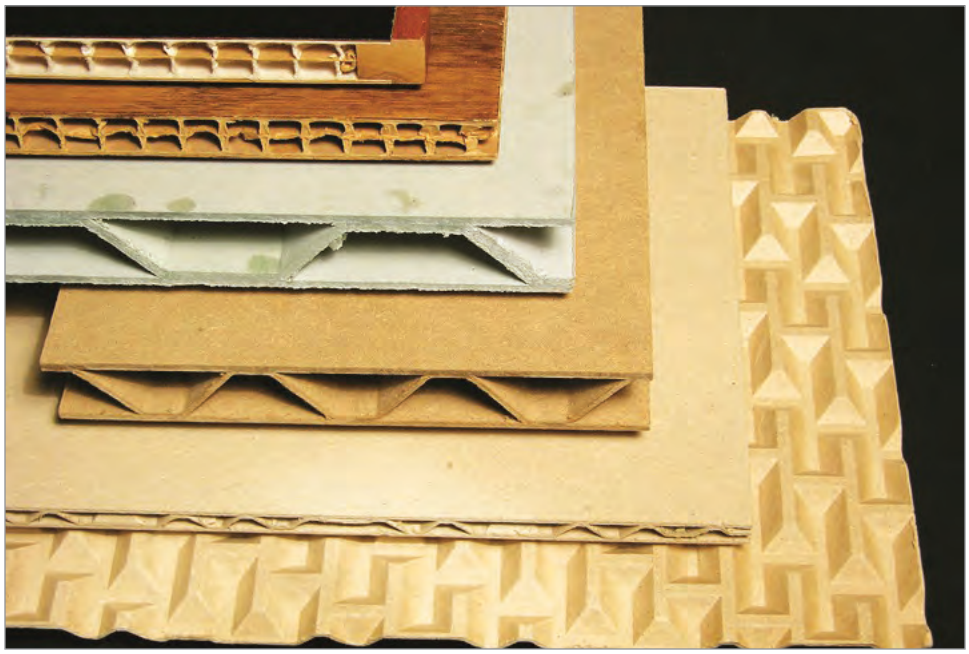
Lead: Forest Products Laboratory

Partnership Produces 3D (3-Dimensional) Engineered Fiberboard Panels

Naturally bonded boards can use fibers produced from a variety of renewable sources including wood from forest thinnings and recycled paper fibers

Biobased structural fiberboard technology has a wide number of design applications and comes from 100 percent renewable and recycled content. Researchers at the Forest Products Laboratory have developed technology whereby cellulose fibers can be formed into structural and 3D engineered fiberboard panels. Noble Environmental Technologies, Inc., of San Diego, CA, a leading sustainable materials manufacturer, has signed an exclusive license agreement with the Forest Service to use jointly developed patent-pending technology and structures for office furniture and packaging applications. These naturally bonded boards can use fibers produced from a variety of renewable sources including wood from forest thinnings and recycled paper fibers.

Noble Environmental Technologies, Inc., announced its exclusive license to commercialize technology based on two patents filed jointly with the Forest Products Laboratory. Such license agreements exemplify the value of public-private partnerships in moving basic research to valuable market-driven applications. A number of global industries and markets will have access to products and processes that are design-versatile, nontoxic, have 100 percent recycled content, and are 100 percent biobased. The collaboration between the Forest Products Laboratory and Noble Environmental Technologies, Inc., is an excellent example of a Government and industry collaboration that works to meet market demands.



Bio-based boards have many applications and are produced from renewable sources including forest thinnings and recycled paper fibers. *Forest Service*

Lead: Forest Products Laboratory

New Cellulose Nanomaterials Pilot Plant Keeps Up With Market Demand

Materials are being supplied to three Government agencies and six partner universities to accelerate the development of advanced cellulose-reinforced composites and printed, flexible electronic circuits and products

In July 2012, the Forest Products Laboratory held a ribbon cutting ceremony to announce the startup of a new Forest Service-funded $1.7 million pilot plant. The pilot plant is now producing about 30 kilograms (kg) of cellulose nanocrystals (CNC), or 5 kg of cellulose nanofibrils (CNF) per week. These materials are being supplied to three Government agencies and six partner universities to accelerate the development of advanced cellulose-reinforced composites and printed, flexible electronic circuits and products. Cellulose nanocrystals are rod-like particles of pure cellulose, about 5 nanometers (nm) in diameter and 150 to 200 nm long. With the strength of steel at one-sixth the weight, the crystals have applications in high-performance composites, replacing Kevlar and carbon fibers. Cellulose nanofibrils are string-like particles, 20 nm in diameter and up to 2 microns long. They form high-strength clear films that can be used in high-performance epoxy layup processes, barrier coatings, or—because of the very low coefficient of thermal expansion—the backing for printed circuits. The new pilot plant enables Forest Service scientists to continue to supply these materials to our partners and make the materials available to dozens of new partner companies. Product applications are diverse and include flexible solar panels, printed electronic circuits, auto body parts, military drones, light-weight armor, and ballistic glass—all of which are under consideration for revamping with this advanced material.

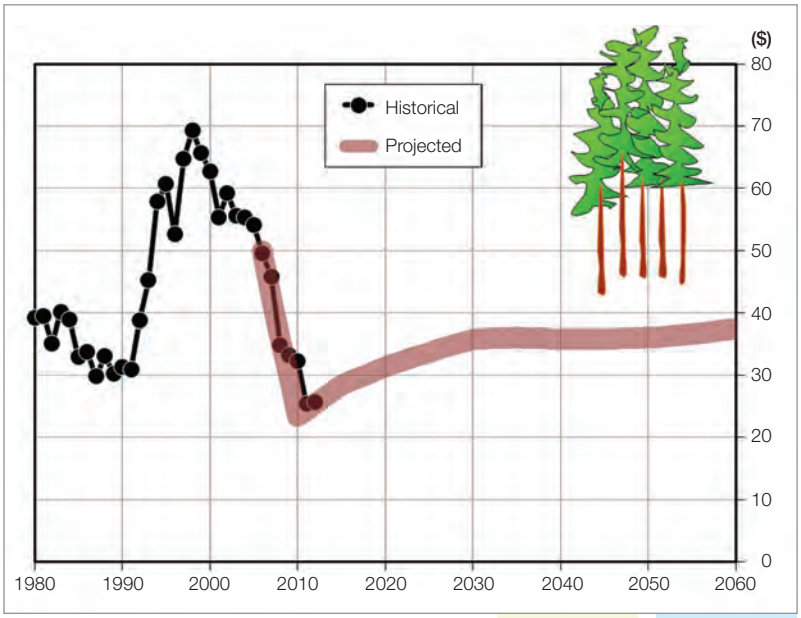
Rick Reiner (right) of the Forest Products Laboratory gave USDA Under Secretary for Natural Resources and Environment Harris Sherman (left) a tour through the nanocellulose facility, explaining its capabilities and the promise this new material offers to a wide variety of industries. *Forest Service*

Lead: Forest Products Laboratory

Economic Model Predicts U.S. Forest Product Markets and Timber Demand Trends

Model provides insights on how U.S. competition and trade in forest products could be affected by expanded global use of wood for energy in future decades

Forest Service researchers developed a detailed model that provides projections of future timber demands and timber prices under alternative scenarios regarding global economic growth and wood energy consumption. The model provides insights on how U.S. competition and trade in forest products could be affected by expanded global use of wood for energy in future decades. The Resources Planning Act (RPA) mandates that the Forest Service provide a periodic national report assessing the U.S. forest resource supply and demand status every 10 years. This report includes long-range projections of forest product consumption, production, trade, and timber market trends, and researchers developed a model that provides such projections. Benefits of this research include a precise and quantitative understanding of how future timber demands and values could evolve under alternative future economic scenarios. The model provides a range of new and expanded capabilities, including modeling regional U.S. forest product production and trade, stumpage markets for hardwood and softwood timber, regional timber harvest and wood residue disposition calibrated to Forest Service timber data acquired through the Forest Inventory and Analysis Program, and the relationship between housing construction and wood product demands. Using global economic scenarios developed for RPA, the model shows that scenarios with large expansion in global use of wood for energy would likely result in large increases in real timber stumpage prices in U.S. regions, but U.S. producers of forest products could still gain competitive advantages if global roundwood prices increase more in foreign countries than in the United States as a result of expanded global wood energy consumption.



Historical data on real prices of softwood sawtimber in the U.S. South and overlapping 2012 baseline projections of prices to 2060 (in 2006 dollars per cubic meter). *Forest Service*

Lead: Forest Products Laboratory

Scientists Find the Achilles' Heel of Wood Fungi Tolerance to Preservatives

Inhibiting the enzymatic pathway in copper-tolerant brown rot fungi can block its tolerance of commercial wood preservatives

Up to 80 percent of commercial wood preservatives contain copper in one form or another to inhibit decay and termite damage, yet most brown rot decay fungi can circumvent the effects of copper by production of oxalic acid and precipitation of the copper. Researchers studied enzymatic activity in these fungi looking for ways to prevent their copper tolerance, thereby saving the taxpayers time and money for replacement of wood decking and lumber treated with copper-based preservatives. The enzymatic activity of major enzymes in the tricarboxylic acid (TCA) cycle and the glyoxylate (GLOX) cycle were quantified to determine the primary pathway of oxalic acid production in economically important wood decay fungi. Analysis of the peak activities revealed a previously undescribed pathway using an enzymatic shunt between the two major cycles. Sharply targeted inhibition of this shunt may prevent production of oxalic acid and any tolerance to copper-containing preservatives exhibited by brown rot fungi.

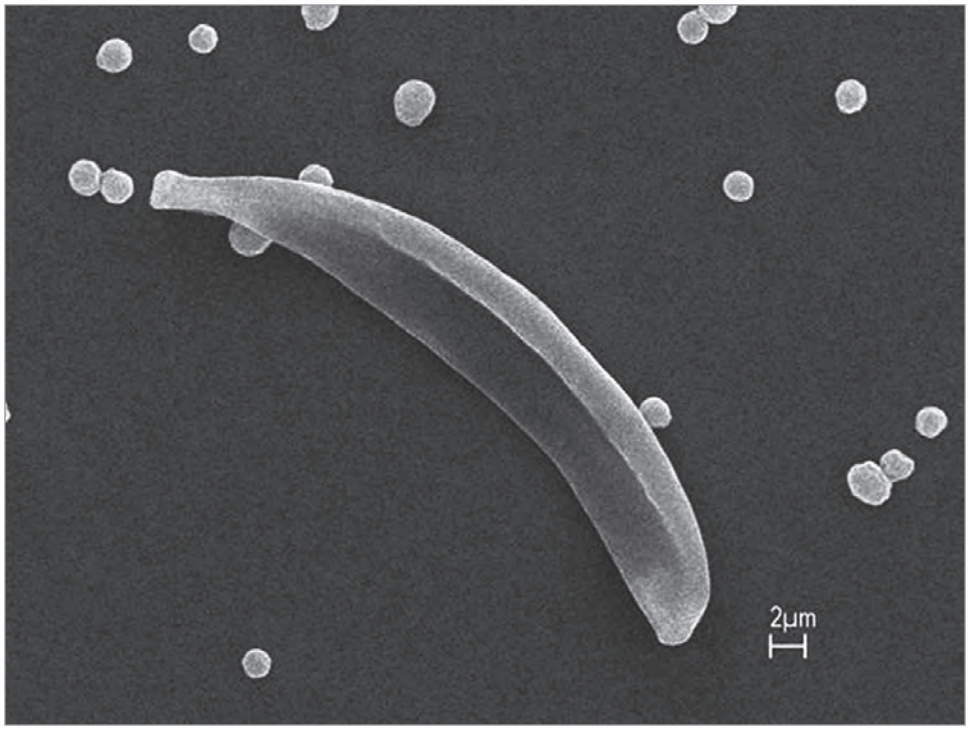
The brown rot fungus Fibroporia radiculosa is very tolerant to copper. *Forest Service*

Lead: Forest Products Laboratory

Novel Yeast Makes Bioconversion Faster and Less Expensive

Faster, cheaper biofuel production is possible for commercial use

A yeast that was isolated from the gut of wood-boring passalid beetles can ferment xylose to ethanol three times faster than the yeast ferments glucose to ethanol, whereas normal yeasts do not ferment xylose at all, or ferment it at a much slower rate than glucose. This yeast can also ferment different sugars simultaneously when presented with a mixture and can ferment xylose to ethanol under anaerobic conditions on minimal medium. All these features are conducive to faster, cheaper biofuels production, and the findings are being developed for possible commercial use. Forest Products Laboratory researchers determined that this highly unusual yeast, *Spathaspora passalidarum*, can convert a mixture of cellulosic and hemicellulosic sugars to ethanol. *Spathaspora passalidarum* was isolated from the gut of wood-boring passalid beetles in the laboratory at Louisiana State University. Collaboration among the university, scientists at the Forest Products Laboratory, the Great Lakes Bioenergy Research Center, and the Joint Genome Institute have enabled the isolation, characterization and genomic sequencing of this highly novel yeast. Genomewide expression studies have identified a number of critical genes that enable cofermentation, and these findings are being developed for possible commercial use.



A highly unusual yeast, Spathaspora passalidarum, is benefitting biofuels production. *Forest Service*

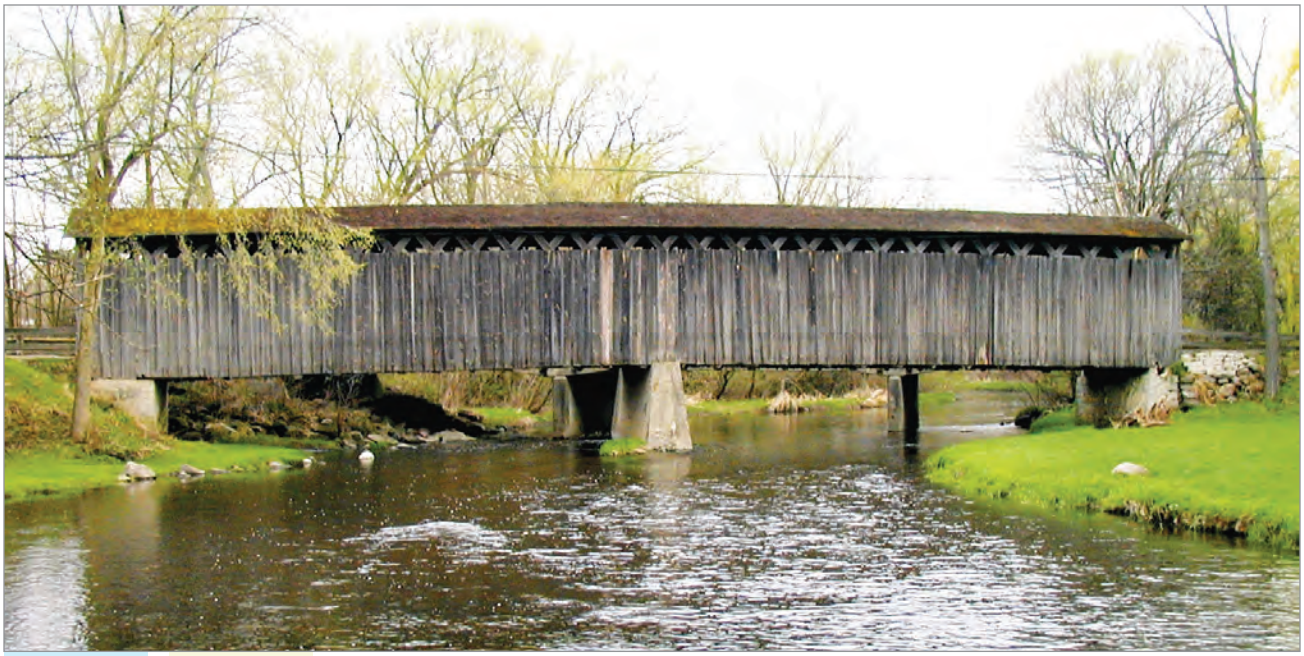
Lead: Forest Products Laboratory

New Guide Advises Treatments and Technologies To Protect Historic Wooden Bridges

Forest Service and university researchers collaborate to evaluate methods of protecting wooden bridges from fire and biodegradation

Wooden bridges, whether historic covered bridges or current highway timber bridges, are vulnerable to damage from biodegradation or fire. Only about 800 of more than 10,000 covered bridges built in the United States are still standing, and many of those are suffering from biodeterioration. The remaining covered bridges are also vulnerable to damage by intentional or accidental fires. Modern timber bridges, which represent an important component of the transportation resource, can also be vulnerable to fire and decay. With funding provided by the Federal Highway Administration, Forest Service and university researchers collaborated to evaluate methods of protecting wooden bridges from fire and biodegradation. Researchers consolidated this research and the resulting recommendations into a guide that provides detailed information on factors that contribute to vulnerability and best practices for minimizing vulnerability, selecting and applying supplemental preservative treatments, use of fire retardants, and fire protection technology. "Guide for In-Place Treatment of Covered and Timber Bridges" is the first of its kind to provide such detailed information and instructions. Historic preservationists and transportation maintenance personnel will use the guide in their efforts to extend the life of historic and modern wooden bridges.

The Cedarburg Covered Bridge in Wisconsin was one of the bridges included in this study. *Forest Service*



Lead: Forest Products Laboratory

Hidden Lives of Wood Decay Fungi Uncovered by Genome Sequencing

The decoded genomes of 12 species reveal a complex repertoire of proteins involved in the deconstruction of key polymers within wood cell walls

Wood decay fungi are common inhabitants of forest ecosystems where they play a pivotal role recycling carbon and other nutrients. For decades, considerable attention has been focused on wood decay fungi because of their unique ability to efficiently deconstruct woody plant cell walls and because certain species are the principal agents that destroy wood in service. Decay fungi are difficult experimental systems, however, and progress has been slow. Forest Service researchers recently sequenced the genomes of 12 species, a major advancement that opens the way for future wood decay fungi research. Forest Service collaborative efforts with the U.S. Department of Energy and 28 laboratories from 10 countries have generated two landmark publications and opened the way for future wood decay fungi research. Researchers sequenced the genomes of 12 species, each predicted to contain at least 10,000 genes, and examined the expression of these genes when the fungi colonized wood. These investigations revealed that a complex repertoire of proteins was involved in the deconstruction of key polymers within wood cell walls, including cellulose, hemicellulose, and the more recalcitrant toward breakdown lignin. The identified enzymes are of particular importance to biorefinery applications where the central goal is often conversion of woody biomass to small molecular weight, high-value products. Analyses also provided explanations for efficient and selective depolymerization of lignin, a longstanding obstacle in the biorefinery area. Thus, a framework for future research on ligninolysis has been opened. In a similar way, identification of genes involved in the decay of wood in buildings offers new opportunities for the development of environmentally benign control practices and preservatives.

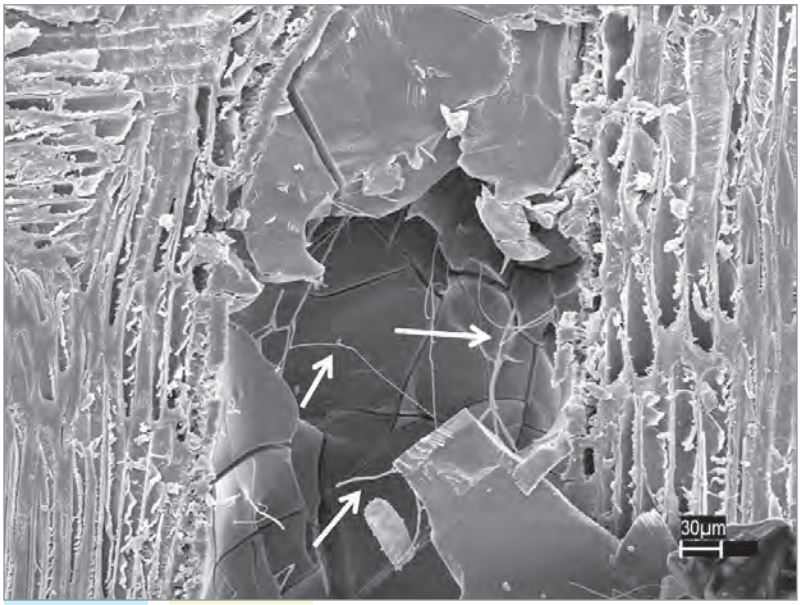
Wood decay fungus Ceriporiopsis subvermispora colonizing wood vessels. *Robert Blanchette, University of Minnesota*

Lead: Forest Products Laboratory

Natural Wood Durability Studied To Estimate Wood's Performance

Naturally occurring chemicals in some wood species make them more durable against deterioration

Naturally durable wood (NDW) has been offered as an alternative to chemically treated wood for the environmentally conscious consumer. Extractives contained in certain wood species are thought to impart natural durability, but extractive content varies drastically based on a variety of factors making performance estimates of NDW difficult. The goal of this research is to provide analyses of the role of extractives, how they improve the durability of certain wood species, and provide reasonable field-based estimates of performance of these materials. The use of naturally durable wood predates treated wood by thousands of years. Many structures thoughtfully constructed of these NDW materials have endured for centuries. The removal of chromated copper arsenate, or CCA, a common chemical wood treatment, from the residential market in 2006 drew attention to the limitations of treated wood in environmentally sensitive areas. As a consequence, several NDW types, such as redwood and western red cedar, were marketed to consumers as alternatives to treated wood. Understanding of the actual mechanisms of the natural durability of wood is limited; however, extractives are believed to be key factors. Forest Service scientists are working to gain a better understanding of the role of extractives as NDW weathers in the natural environment, and the effect of extractives on the microbes that drive wood deterioration. Nine candidate NDW species are being evaluated in aboveground and laboratory tests to develop recommendations for consumers interested in using NDW in nonstructural applications. DNA (deoxyribonucleic acid) extracted from fungi and bacteria that are colonizing the woods is being analyzed to see if different microorganisms attack different wood species. Chemical analyses are being conducted to determine the different chemical components found in NDW and how those components change during outdoor exposure.



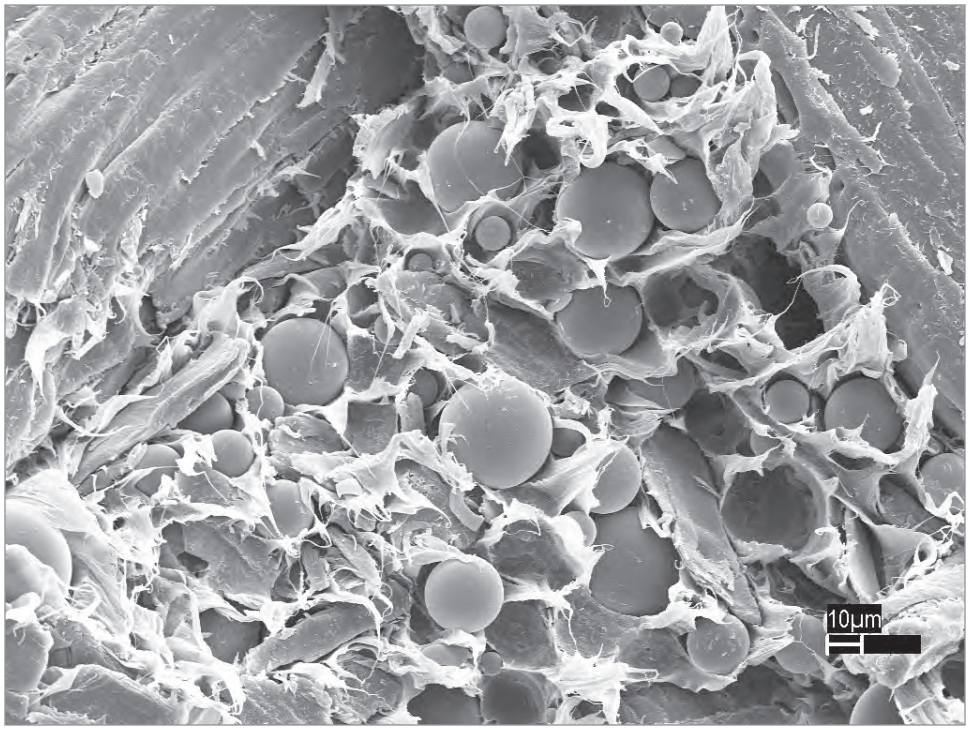
An unidentified waxy substance in honey mesquite cells creates a physical barrier against fungal hyphae. *Forest Service*

Lead: Forest Products Laboratory

Wood-Plastic Composites Improved With Glass

Adding microsized glass particles to wood-plastic composites creates a less dense but stiffer material for use in a variety of building applications

Wood-plastic composites are widely used, particularly in building applications. Two drawbacks of these composites, however, are their high density and low stiffness. In cooperation with 3M, Forest Products Laboratory researchers are adding hollow glass microspheres to wood-plastic composites, making them stiffer, lighter, and more easily fastened. Wood-plastic composites combine wood flour, plastics, and small amounts of other materials to produce a composite with a favorable balance of properties. These composites are a major outlet for recycled film and are often used in exterior building applications including roofing, fencing, siding, window and door profiles, railings, and especially in decking. These materials are also more easily fastened using standard fasteners such as nails and screws. Optimization of processing parameters was important to prevent the hollow glass microspheres from breaking under the high pressures used in producing these next-generation composite materials.



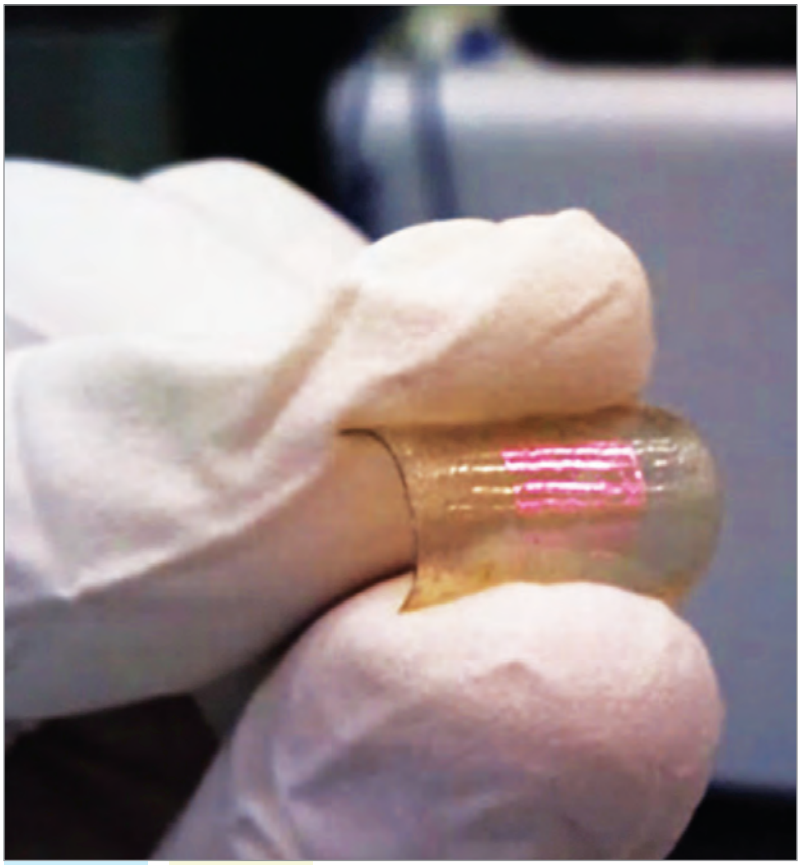
Hollow glass microspheres in wood-plastic composites. *Forest Service*

Lead: Forest Products Laboratory

Cellulose Nanofiber Composites Can Serve as Substrate for Flexible Electronics

Transparent films made from cellulose nanofibers have low thermal expansion and the potential to serve as a foundation for flexible electronics

Flexible electronics have many potential applications including malleable displays, solar cells, smart cards, radio frequency tags, medical implants, and wearable computers. Transparent films made from cellulose nanofibers, a renewable nanomaterial, have low thermal expansion and thus the potential to serve as a foundation for flexible electronics. Forest Service researchers recently demonstrated the ability to transfer silicon nanomembranes onto flexible plastic substrates to create working thin-film transistors having a 12-gigahertz maximum oscillation frequency. Current work with high-speed, flexible electronic substrates uses plastics for the flexible substrate. These plastics typically have drawbacks, however, such as high thermal expansion coefficients. Transparent films made from cellulose nanofibers, a renewable material using the smallest workable particles of wood, have low thermal expansion, and thus, the potential to serve as a superior substrate for flexible electronics. Researchers from the Forest Products Laboratory and University of Wisconsin, Madison, have demonstrated the first example of using cellulose nanofiber composite substrates for flexible electronics. Although some challenges remain, the cellulose nanofiber composite showed good chemical and thermal resistance, which is necessary for electronic fabrication, and the use of cellulose nanofibers as a sustainable component for high-speed flexible electronics is extremely promising.



Flexible electronic substrate made from cellulose nanomaterial. *Forest Service*

Lead: Forest Products Laboratory

Wood-Plastic Composites Are More Desirable With Fire-Retardant Treatments

Wood-plastic composites treated with fire retardants address fire concerns in the wildland-urban interface

Wood composites made with highly flammable plastics are increasingly being used in a wide range of applications. Such applications include decking boards and other exterior products around homes in the wildland-urban interface. Tests have shown that fire-retardant treatments can reduce the potential contribution of the wood-plastic composites to a fire. Wood-plastic composites are widely available for some building applications. In applications such as outdoor decking, these composites have gained a significant share of the market. As part of efforts to address fire concerns in wildland-urban interface, the Forest Products Laboratory has been examining the fire performance of wood-plastic composites. As a followup to initial studies on commercial decking products and untreated wood-plastic composites, Forest Service scientists and international visiting scientists from Turkey evaluated fire-retardant treatments for these composites. Scientists conducted heat-release rate tests at the Forest Products Laboratory on untreated and fire-retardant-treated wood-plastic composites to determine the effectiveness of the fire-retardant treatments. The rate of heat release due to combustion is an important parameter in the ability of a burning material to spread rapidly and contribute to the intensity of a fire. Studies showed that increasing the wood fiber content in wood-plastic composites significantly improved the fire performance to that of the plastic alone. Adding fire-retardant chemicals, particularly ammonium polyphosphate, was also shown to be effective in improving the fire performance.

Fire-retardant treatments can reduce the contribution of wood-plastic composites to a fire. *Forest Service*

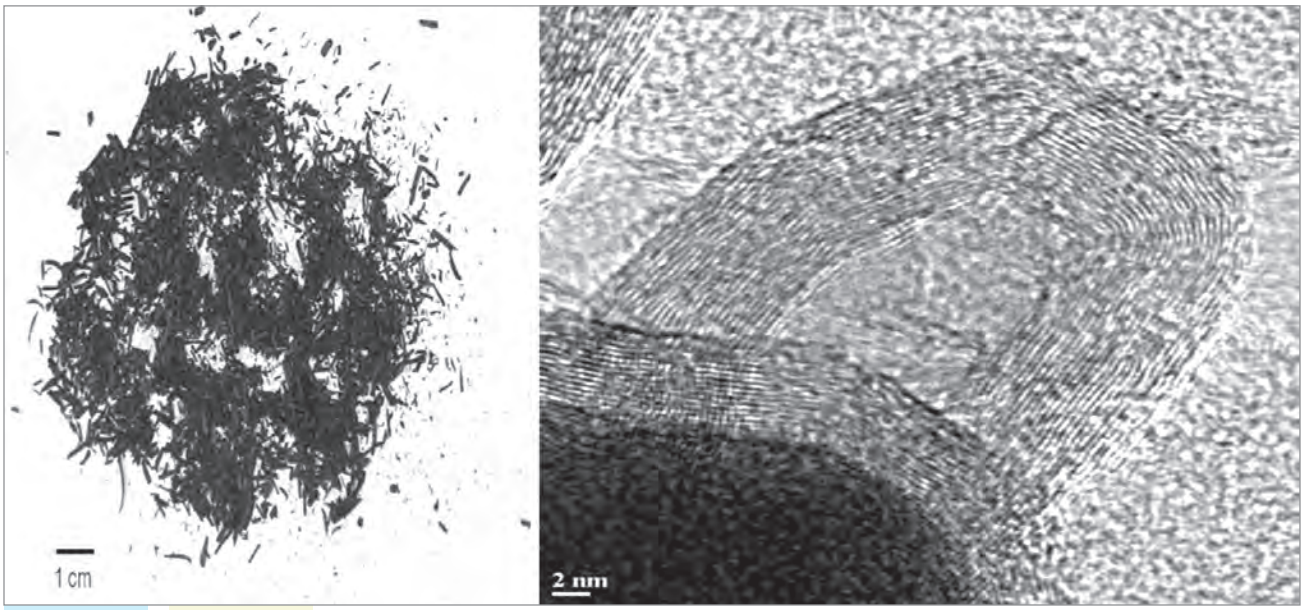
Lead: Forest Products Laboratory

Metal Core Nanoparticles Created From Wood Char, a Bioenergy Byproduct

Shell-encapsulated metal core carbon nanoparticles have potential applications in magnetic data storage, xerography, drug delivery, and as a catalyst in other chemical reactions

In the late 20th century, several synthetic carbon allotropes were discovered. These materials are new molecular configurations of carbon with unique physical properties that differ from naturally occurring forms of carbon at the smallest level, the nanoscale. More recently, another new type of nanostructured carbon material, carbon shell-encapsulated metal core nanoparticles (CSEMCNs), has been reported. Typical CSEMCNs have a core-shell structure wherein metal core elements are surrounded by multilayer carbon shells. Wood char is a byproduct from wood chips using fast pyrolysis, a thermochemical conversion method used to produce energy from biomass. Using wood char for fabricating CSEMCNs will provide added value for this bioenergy byproduct. In this study, Forest Service scientists synthesized CSEMCNs by heating wood char, either control or preimpregnated with metal ions, at 900 to 1,100 °C. As a result, CSEMCNs were formed with metal cores surrounded by multiple carbon shell layers.

Transmission electron microscopy and x-ray diffraction analysis indicate that the carbon shells have structures similar to that of graphite, with an average interplanar distance of 0.34 nanometers. The energy dispersive x-ray spectrum shows that carbon is the dominant element in the lattice fringe. The preimpregnation of metal ions in wood char improves the CSEMCNs yield.



Wood char particles and carbon-encapsulated iron nanoparticles. *Forest Service*

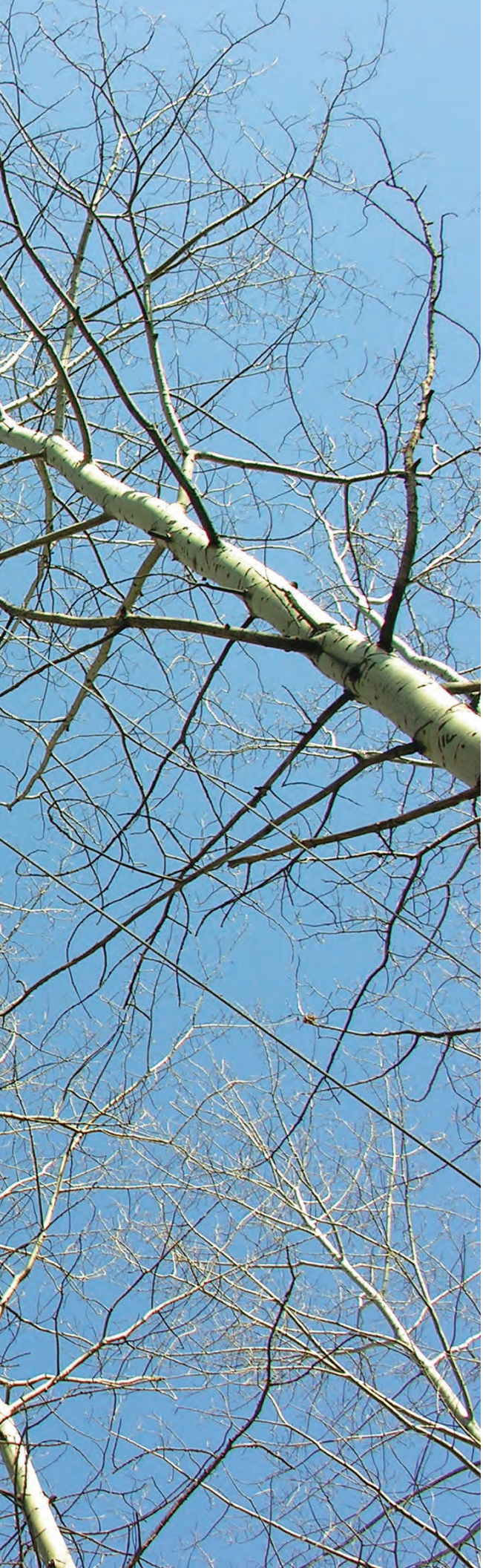
Lead: Forest Products Laboratory

New SPORL Process Efficiently Converts Biomass to Sugars and Ferment

Preliminary laboratory evaluation confirms the high performance of the SPORL process for pretreatment of Douglas fir

In general, softwoods are considered the most difficult biomass raw material for a biorefinery to convert to sugars and ferment. A process known as SPORL (sulfite pretreatment to overcome recalcitrance of lignocellulose) is uniquely efficient as a pretreatment for softwoods such as Douglas fir and is vital to the Northwest Advanced Renewables Alliance regional biomass project. In September 2011, the U.S. Department of Agriculture announced that Washington State University would receive a 5-year, $40-million grant to help develop alternatives to petroleum-based fuels and chemicals. The Forest Products Laboratory received a $1.1-million subcontract to pretreat woody biomass for conversion to aviation fuel. The laboratory's part was to demonstrate the SPORL process for efficient sugar production from Douglas fir forest residue. In the first year of the project, the scientists developed a fractionation technique to reduce the bark content of forest residues. The goal is to leave the bark in the forest for soil conditioning and nutrients. Improved bark removal also reduces the deadload in transportation and biorefinery processing. Preliminary laboratory evaluation has confirmed the high performance of the SPORL process for pretreatment of the Douglas fir, providing efficient enzyme conversion to sugars and high biofuel yield.

Lead: Forest Products Laboratory



Water, Soil, and Air

The Water, Air, and Soil Strategic Program Area 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 among water, air, and soil research. The program area notes the effects of climate variability and change on water budgets.

Lichen Communities Serve as "Canary in the Coal Mine" for Air Pollution

A comparison of lichen communities from 1976 to 2008 suggests continued deterioration of air quality in the Los Angeles Basin despite policy and technological advances

The heavily urbanized Los Angeles Basin in southern California has experienced poor air quality since the early 1940s, and forest structure in the region has been shaped by severe smog incidents and chronic nitrogen deposition. Lichens are highly responsive to nitrogen, and monitoring species changes is an inexpensive method for evaluating local air-quality effects on forests. In 2008, Forest Service scientists looked at species composition of lichen communities growing on trees in the Cleveland National Forest, San Bernardino National Forest, and Angeles National Forest to assess the current state of air quality. These sites were previously inventoried in 1976 and 1977. At that time, researchers concluded that more than 50 percent of lichen species were locally extinct since the lichen flora was first documented in the early 1900s. Lichen communities in all three forests showed symptoms of worsening of air quality. No sensitive lichen species had recolonized trees since that time, and the abundance of nitrogen-loving species associated with polluted areas had increased, in some cases dramatically. Declines were most severe for the Palomar region of the Cleveland National Forest, which was formerly determined to be relatively clean in 1976 and 1977, based on its lichen communities. This information can be used to help guide future air-quality monitoring activities planned for southern California.

Quercus kelloggii lichen grows in the San Bernardino National Forest that receives about 70 kilograms of nitrogen per hectare per year—background levels are less than 1 kilogram. *Forest Service*

Lead: Pacific Northwest Research Station

Dam Removal Produces Largest Release of Sediment in History

Four years of research on the Sandy River after the removal of the Marmot Dam provides guidance for future dam removals

During the past decade, the number and size of dams removed on rivers across the United States has been increasing. Dam removal typically involves the release of at least some of the sediment stored in the reservoir behind the former dam. When released sediment moves downstream, it has the potential to dramatically change the form and behavior of the downstream channel. Nowhere has this been more closely studied than on the Sandy River, outside Portland, OR, after the removal of Marmot Dam in 2007. At the time, its removal produced the largest intentional release of sediment from any dam removal in history. A new report describes how the Sandy River responded to the release of sediment during the next 2 years. Key findings include: (1) an energetic river can rapidly incise and remove large volumes of unconsolidated stored sediment, even under very modest flows; (2) channel change is initially quite rapid but diminishes over time as sediment sources diminish; (3) allowing rivers to naturally process stored sediment rather than manually removing it before dam removal may be a tractable option for coarse, clean sediment in cases where sediment deposition will not create a flood risk downstream.

The Marmot Dam on the Sandy River in Oregon was breached in October 2007 to improve habitat for salmon and steelhead. *Forest Service*

Lead: Pacific Northwest Research Station

Sources of Air Quality in the Lake Tahoe Basin Analyzed

Scientists determine elevated concentrations of ambient ozone in the Lake Tahoe Basin are caused mainly by local emissions

In the summer of 2010, Forest Service scientists conducted a study in the Lake Tahoe Basin to address the distribution of ozone in time and space and that of its chemical precursors, volatile organic compounds, and nitrogen oxides. The scientists selected 34 air-quality monitoring sites at different elevations inside and out of the basin. They used passive samplers to determine the concentrations of volatile organic compounds, nitrous oxides including the common pollutant nitrous dioxide, and ozone. Real-time ozone monitors at a subset of 10 sites were used to evaluate changes of this pollutant during a 24-hour period. The scientists determined that high concentrations of ozone found on the western slope of the Sierra Nevada are caused by air-pollution emissions from the California Central Valley, which rarely get into the Lake Tahoe Basin. Elevated ozone concentrations on the eastern side of the basin at the high-elevation sites indicated the ozone likely originated from local emission sources. High-ozone concentrations in the middle of Lake Tahoe most likely originate from powerboat emissions and the high intensity of photochemical processes taking place at that location. The research results will help land managers and community leaders develop strategies to improve air quality in the Lake Tahoe Basin.

Forest Service rangers and passive samplers in Desolation Wilderness. *Forest Service*

Lead: Pacific Southwest Research Station

Industrial Air Pollution May Have Ecological Consequences

Elevated concentrations of ammonia can negatively impact lichen communities, and elevated levels of nitrogen and sulfur deposition can potentially harm boreal forests and other ecosystems

The Athabasca Oil Sands Region in Alberta, Canada, contains boreal forests where epiphytic lichen communities are increasingly at risk from industrial air pollutants emitted by mining, oil extraction, and upgrading operations. (Epiphytics rely on other plants for physical support, growing on trunks and branches rather than rooting themselves to the ground. They are not parasitic because they do not derive any nutrients from their hosts.) The concentrations of industrial emissions in the Athabasca Oil Sands Region are rising as the area of exploited oil sands and rate of bitumen production continue to expand. Ambient air pollutants of biological importance (ammonia [NH_3], nitrogen oxides [NO_2], nitric acid [HNO_3], and sulfur dixode [SO_2]) and atmospheric deposition of nitrogen (N) and sulfur (S) have been monitored by a Forest Service team sponsored by the Wood Buffalo Environmental Association since 2005. Concentrations of these compounds and N & S deposition decline sharply with distance from the industrial center. Although levels of the measured pollutants do not indicate direct toxic effects to vegetation, sensitive epiphytic lichen communities could be affected by elevated NH_3 concentrations. As a consequence, NH_3 is of highest importance among the measured pollutants because of its high biological activity and high contribution to nitrogen deposition. In the most polluted areas, elevated N and S deposition may have significant ecological consequences for forests and other ecosystems, such as acidification and changes in the nutritional status of vegetation.

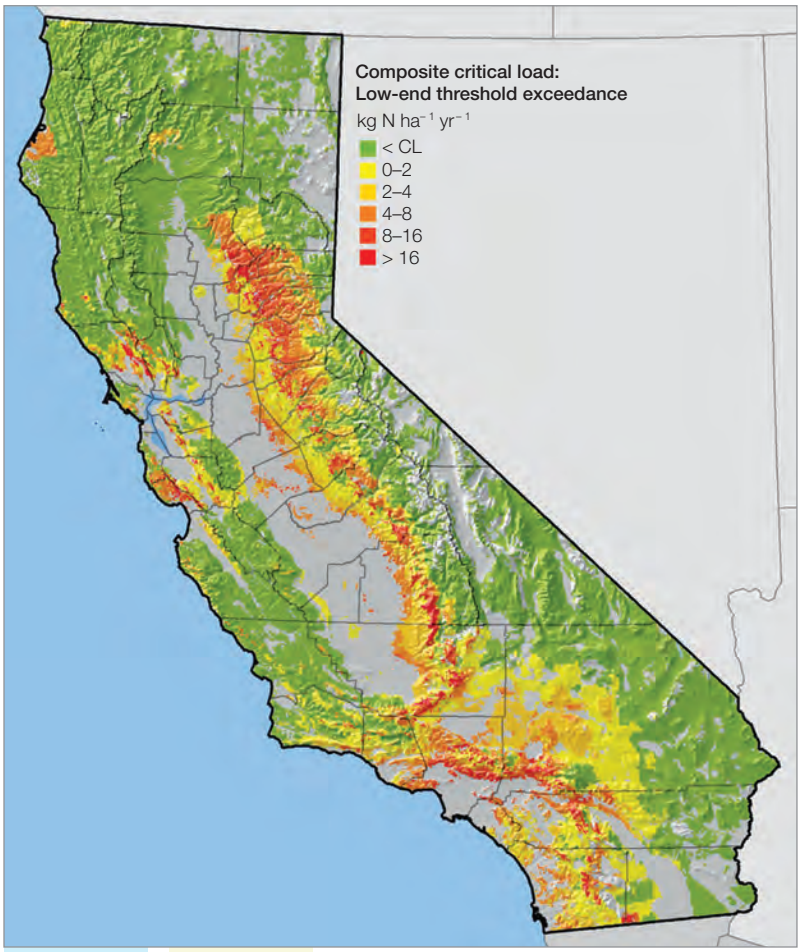
Passive samplers for air pollution in Athabasca oil sands region. *Forest Service*

Lead: Pacific Southwest Research Station

Air-Pollution Thresholds Protect Ecosystems

Research benefits air-quality specialists, land managers, scientists, and policymakers

In recent years in the United States, a recognition has grown for the need to define the critical loads of atmospheric pollution inputs, which put natural resources and ecosystem services at risk. Recent advances led by Forest Service scientists in defining thresholds for acceptable air-pollution exposure have greatly increased U.S. capacity to protect and restore at-risk ecosystems. The use of these thresholds applies to toxic, acidic, and bloom-inducing effects on aquatic and terrestrial ecosystems that are affected by pollutants such as mercury, sulfur, and excess nitrogen. The research took place primarily during the past decade in all major regions of the United States. Air-pollution studies in California formed an important part of these efforts. The Forest Service, National Park Service, and other entities use the critical loads developed in this work for natural resource protection. Another aspect of this work is a synthesis of empirical critical loads for atmospheric nitrogen deposition effects for major ecoregions of the United States. The synthesis included U.S. maps showing regions where ecosystems are at risk from the harmful effects of nitrogen deposition. A related high-profile report geared for a broad audience was published on the use of air-pollution thresholds in policy and to protect and restore U.S. ecosystems. Last, a federally mandated peer-reviewed report was submitted to Congress that provided an update on the status of pollutant emissions, atmospheric deposition, ecosystem effects, and projections of emissions necessary to prevent future adverse ecosystem effects in the United States.



Composite critical load exceedance map for seven major vegetation types in California. The figure indicates areas where and by how much atmospheric nitrogen deposition is higher than the critical load (e.g., threshold) for risk of harmful ecological effects. *Forest Service*

Lead: Pacific Southwest Research Station

North American Forest Soils Are Remarkably Resistant

Ten years of data on 45 locations in the United States and Canada illustrate exactly how much disturbance forest soils can undergo and still remain productive

The Forest Service began its Long-Term Soil Productivity program in 1989, and it is the largest coordinated study of managed forests in the world. A recent report from the program describes 10 years of results for 45 study sites that are located throughout the United States and Canada. Although all individual regions or sites did not fit the trend, no consistent effect was seen in tree biomass growth 10 years after whole-tree harvest and severe compaction. In fact, some sites in the boreal region responded favorably to the complete removal of the organic forest floor, and some sandy sites had improved water-holding capacity after being compacted. Controlling noncrop vegetation had substantial and sustained positive effects on productivity. Although many sites have only recently reached canopy closure, and some responses may change with time, this work provides ample evidence of managed forest soil's resistance and resilience to one-time disturbances across wide climatic and geologic gradients.

Long-Term Soil Productivity plot in Missouri. *Forest Service*

Lead: Southern Research Station

Quantifying Phosphorus Delivery Pathways in Forest Watersheds

Predictive model clearly shows the importance of lateral flow in delivering phosphorus from steep forested hillslopes to forest streams

Forest streams and lakes are renowned for their clarity, but concern that forest streams are carrying excessive amounts of phosphorus is increasing. Over the years, Forest Service scientists have helped the managers of forest watersheds better understand sources of phosphorus in Big Bear Lake in the San Bernardino National Forest, in Lake Tahoe on the California-Nevada border, and in the Great Lakes, where more than 60 percent of the basin is forested. When phosphorus pollutes rivers and lakes, algal growth becomes excessive. When algae die and decompose, they can poison the water or make fish in the water poisonous for human consumption. The process also removes oxygen from the water, which sometimes leads to the death of vulnerable fish species. Current phosphorus models focus on agricultural systems where animal manure and chemical fertilizer tend to dominate phosphorus management and delivery issues. In these systems, phosphorus delivery is associated with surface runoff and erosion. Agricultural models will not work in forest watersheds where minimal concern about livestock manure exists, where chemical fertilizers are seldom used, and where surface runoff and erosion rates are minimal compared with agricultural settings. Forest Service scientists developed the Water Erosion Prediction Project (WEPP) model for forest conditions, which has been in use for more than 20 years. One of the more recent improvements within WEPP technology is the addition of shallow lateral flow as one of the primary sources of runoff from steep forested watersheds. Concurrent with this development, scientists observed that phosphorus concentration, although relatively low in forest soils, was relatively high in forest soil water. The scientists merged these two disparate pieces of information to develop a phosphorus delivery model that includes surface runoff and sediment delivery, plus delivery of phosphorus with lateral flow. The resulting predictive model clearly shows the importance of lateral flow in delivering phosphorus from steep forested hillslopes to forest streams. One of the interesting findings is that the soil water phosphorus concentration is frequently lower after thinning or prescribed fire, suggesting that fuel management activities aimed at reducing the risk of wildfire may also reduce the delivery of phosphorus in lateral flow. Research will be continued to better understand these interactive processes that are associated with phosphorus delivery from forested watersheds. A user-friendly version of the model will be released soon for application in the Lake Tahoe Basin.

Lead: Rocky Mountain Research Station

Improved Air-Quality Models Help Land Managers and Regulators

New research helps reduce the effects of wildfire emissions on human health, economic activity, and scenic integrity

Wildland fires are a significant source of air pollutants. These pollutants present significant regulatory challenges associated with National Ambient Air Quality Standards, the Regional Haze Rule, and forthcoming greenhouse gas regulations. The production, transport, and transformation of these primary and secondary pollutants from fires must be better understood to minimize their effect on human health, economic activity, scenic integrity, and ecosystem resiliency. Air-quality regulators and land managers employ smoke modeling systems to predict, evaluate, and manage the effect of fire emissions on air quality. Although much progress has been achieved recently in understanding the smoke chemistry of prescribed burning, significant knowledge gaps regarding the chemistry of wildfire smoke have hindered the development of reliable smoke modeling systems. The Forest Service's Smoke Emission and Dispersion Research Team conducted a multiyear smoke chemistry research project to evaluate emissions from wildfires in the Western United States. The Joint Fire Science Program, Forest Service Research and Development, and the National Fire Plan financially supported the effort. Researchers installed smoke chemistry measurement instruments on a Forest Service aircraft and measured fresh emissions and smoke dispersion from 25 wildfires in the Western United States. They found that wildfires in the Interior Mountain West burn with a much lower combustion efficiency than prescribed fires. This finding means that for a given mass of vegetation burned, wildfires emit more fine particulate matter ($PM_{2.5}$) and more nonmethane organic compounds (NMOC) that lead to ozone (O_3) formation. These results indicate previous estimates of wildfire emissions underestimated the production of these pollutants and the potential of wildfires to degrade local and regional air quality. This research improves wildfire emission inventories and air-quality models and enhances their ability to minimize and mitigate the effects of wildfire emissions on human health, economic activity, and scenic integrity.

Plume of the Big Salmon Lake Fire—one of 25 fires studied in the Smoke Emission and Dispersion field project—on August 17, 2011. *Forest Service*

Lead: Rocky Mountain Research Station

Prairie Strips Lead to Better Environmental Health and Greater Socioeconomic Vitality

Forest Service scientists help Midwestern farming communities understand how to transform strategic portions of the agricultural landscape into perennial plant communities

The Forest Service and its partners are helping Midwestern farming communities understand how to transform strategic portions of the agricultural landscape into perennial plant communities and, thereby, enhance environmental quality and socioeconomic vitality. The goal of the study is to develop a new paradigm for farming to develop landscapes that reduce nonpoint-source pollution, increase plant and animal diversity, and decrease fertilizer inputs into crop production, while still maintaining economic viability. Researchers are establishing baseline conditions, quantifying the potential benefits of perennial vegetation in watersheds dominated by row crops, and developing decision support tools that can help evaluate tradeoffs. They are already seeing some compelling results related to the benefits of strategically located prairie strips in reducing sediment and nutrient transport to streams (and thus ultimately to the Gulf of Mexico). Other research is indicating that bird diversity is greater where perennial strips exist. Predatory insect populations are also greater where land has prairie strips, leading to lower insecticide inputs that are necessary to protect the corn and soybean crops. The partners have developed a handbook for growers and agency personnel describing the potential benefits of perennials in agricultural landscapes and techniques that achieve those benefits. The results are now being incorporated into field days and training sessions for Iowa farmers.

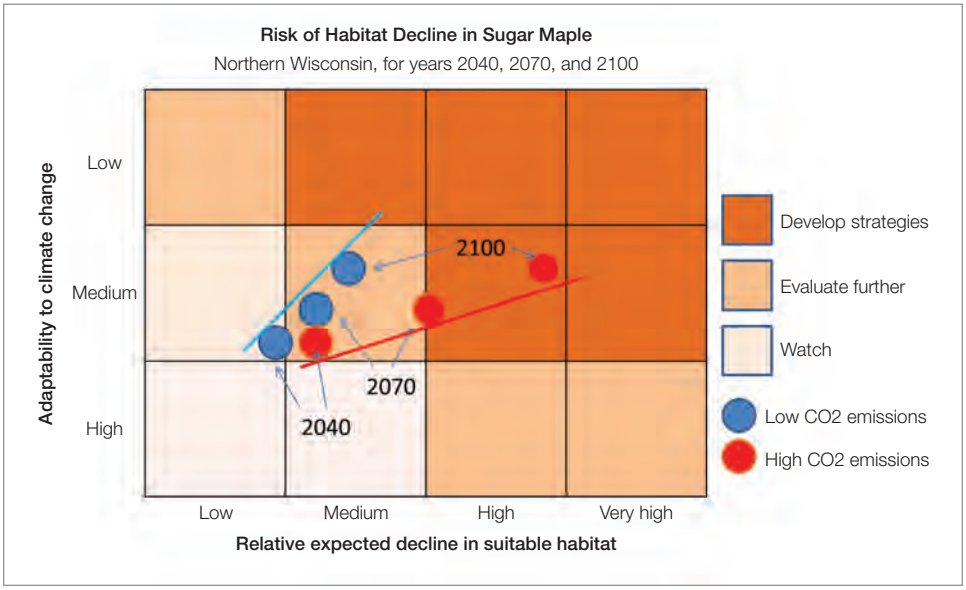
Prairie strip embedded in an agricultural (corn) watershed. Prairie strips increase nutrient and sediment retention, reduce runoff, and increase biodiversity. *Iowa State University*

Lead: Northern Research Station

Assessing Climate Change Risk to Eastern Forests With Climate Change Tree Atlas Data

New tool makes for better informed forest management decisions

Forest Service scientists are using models of potential change of 134 tree species in the Eastern United States, along with their life history characteristics, to prepare risk matrices that capture the likelihood of change along with the adaptability of a species in relation to projected climate changes. The models also provide a visual guide that allows forest managers to quickly assess species for their relative urgency in developing management strategies. Every day, forest managers face a multitude of decisions that must be made based on imperfect knowledge of forests and other ecological systems, and the potential effects of climate change add another dimension to these decisions. As climatic change increases its interaction, mostly negative, with other environmental factors, an urgency is increasing to integrate broad-scale climate modeling outputs with contemporary management decisions. Forest Service scientists are addressing this need with the development of a data-driven approach to evaluating climate change risk among multiple species in which managers can prioritize the most, or least, sensitive forest species within their specific region of interest. This tool incorporates and synthesizes results for projected changes in habitat for 134 tree species and assesses a species potential to adapt to climate change based on their complexity of life history characteristics. The two dimensions of the risk matrix capture likelihood and consequence of climate change effects for each species in a particular geographic area and provide a visual guide to quickly assess species for their relative urgency in developing management strategies.



Climate change risk matrix captures the likelihood and consequence of potential habitat change for sugar maple in northern Wisconsin. *Forest Service*

Lead: Northern Research Station

New Research Suggests Clean Air Act Amendments of 1990 Have Reduced the Exposure of Tree Roots and Surface Water to Harmful Aluminum

Wood decay fungi add humus to the forest floor with a high proportion of essential calcium and low amounts of potentially toxic aluminum, which are conditions found in favorable growing sites not affected by acid rain

National regulation and forest biology have reduced some of the threats posed by acid rain. Recent research by Forest Service scientists suggests that the reduced deposition of sulfates with the Clean Air Act Amendments of 1990 have reduced the mobilization and exposure of tree roots and surface water to harmful aluminum. This reduction is important because aluminum can be directly toxic to fish and other aquatic life and can be indirectly toxic to trees and other plants. Under acidic conditions, aluminum blocks the use of calcium by tree roots and tends to displace essential calcium stored in soil organic matter. Additional research points to the fundamental role of forest fungi and the wood decay process that contributes organic matter that is high in calcium and low in aluminum. The common bricktop wood decay fungus was found to occur in decaying logs, the forest floor, and underlying mineral soil, beyond the reach of most tree roots. This finding suggests that wood decay fungi could use the energy stored in decaying wood to translocate essential chemical elements from deep down in the vertical soil profile up into the tree rooting zone. This process is a potential biological mechanism that restores a healthy chemical environment for forest growth.

Decayed red spruce (Picea rubens) penetrated by fine roots, mycelium, and mycelial cords after 12 years in ground contact. Cords are pathways for wood decay fungus to exchange chemical elements between decaying wood and forest soil. *Forest Service*

Lead: Northern Research Station

Forest Carbon Estimates Generate Climate Benefits Projects Around the World

Science on forest carbon benefits developed by the Forest Service contributes to a reduction in deforestation and degradation in forests throughout the world

Scientifically and operationally, estimating carbon as a global environmental benefit of forest related projects is an active area of debate and is complicated by ongoing international negotiations. A Forest Service scientist worked with colleagues from around the world while on an Intergovernmental Personnel Act detail with the Climate and Chemical Team at the Global Environmental Facility (GEF). The GEF is an independently operating financial organization that provides science-based estimates for proposed forest carbon and sustainable forest management/ REDD+ (reducing emissions from deforestation and degradation) projects. Billions of dollars pledged by donor countries, including the United States, flow through the GEF for projects that include sustainable forest management; land use, land use change, and forestry; and REDD+ projects. One notable program proposal the Forest Service researcher worked on is the Great Green Wall of Africa Initiative which involves 12 countries. Throughout the detail, the scientist consulted with Forest Service colleagues in international programs and other units for up-to-date scientific information. This effort enabled the GEF to begin funding on-the-ground forestry projects for carbon and multiple other global environmental benefits, which include reducing deforestation and increasing carbon stocks in forests.

World Bank/Global Environment Facility personnel learn about Forest Service efforts in climate change mitigation and adaptation in Baltimore, MD. *Forest Service*

Lead: Northern Research Station

Seasonality and Forest Succession in Tropical Watersheds Affects Stream Export

Continuous export of organic matter from mountain streams depends on forested headwaters contributing leaf litter of varied quantity and quality year round

The export and retention of leaf litter greatly influences water quality, food webs, and habitat structure of forested headwater streams. In the Bisley Experimental Watersheds, Forest Service scientists determined leaf litter exported from streams varied in terms of nutrient quality between the dry and wet seasons during a 15-year study. Variation in the quantity and quality of exported material depended on traits of particular weather events, such as storms and hurricanes, season, and the successional status of the forest. The chemical composition of exports varied over time, with the proportion of carbon to nitrogen being highest (low quality for consumers) in the driest months and lowest (high quality for consumers) during rainy months. The differences in export quality signaled that more attention should be given to changes in seasonal rainfall in the tropics, because these changes not only affect stream discharge and timing of new leaf and flower production but also increase the seasonal range in quality of organic matter exports that reach streams. In conclusion, the state of watershed vegetation development limited the quantity of material that was exported during a storm. This finding is independent of the level of hillslope or stream runoff. The synergy between hurricane intensity and frequency and the level of vegetation maturity defined the long-term pattern of high leaf-litter export events in forested watersheds. Headwaters under nonforested land cover conditions may not be able to retain and process a large percent of leaf-litter inputs, which in turn affects water quality and resource availability for aquatic ecosystems downstream. With these findings in mind, watershed and aquatic wildlife managers should consider that changes in the quality of organic matter in streams could potentially alter ecosystem processes and the aquatic food webs that depend on them.

Red bulletwood (Manilkara bidentata) leaf in a stream flow. *Forest Service*

Lead: International Institute of Tropical Forestry

Photo credit: R.C. Wilkinson, University of Florida

Wildland Fire and Fules

The Wildland Fire and Fuels Strategic Program Area 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 fires; evaluating integrated management strategies and disturbance interactions; and applying fire research to management problems.

Testing Fuel Treatments in Boreal Forests

A first-of-its-kind study tests the effects of fuel treatment on fuel consumption and fire behavior in Alaska's boreal forest

Mechanical and manual fuel treatments have become the preferred strategy for reducing fire hazards in the boreal forest. Before this study, however, the actual effects of these fuel treatments on fire behavior and fuel consumption in boreal forests had not been measured. To fill this gap, scientists assessed two major fuel treatment options: thinning trees and mechanical shearing of trees and shrubs. The assessment was done by measuring fire behavior and consumption of fuels on the forest floor after a stand-replacement, prescribed fire. Scientists found that both treatments decreased fire behavior, although the thinning treatments were the more effective of the two. The Alaska Fire Service, Bureau of Land Management, and Alaska State Division of Forestry are using these findings to develop policies that will apply the most effective and least costly fuel treatment to the landscape for community protection from wildfire.

Field crew measure the amount of remaining fuel on the forest floor after a prescribed burn on Nenana Ridge, Alaska. *Forest Service*

Lead: Pacific Northwest Research Station

National Study Evaluates Fuel Treatments in Reducing Risk of Fire

Mechanical treatments do not serve as surrogates for fire treatments

The National Fire and Fire Surrogate study was designed to evaluate how alternative fuel reduction treatments influence a multitude of ecological effects in seasonally dry forests.

A new report summarizes results from 206 technical articles stemming from the 12 sites of this national study. Some general conclusions can be drawn from the report. For example, for most sites, the treatments modified stand structures and fuels to the point where post-treatment stands are expected to be much more resistant to moderate wildfire. Although ecological effects tend to dampen with time, fire risk appears to increase due to treatment-induced collapse of burned portions of stands. Mechanical treatments do not serve as surrogates for fire for most ecosystem components, suggesting that fire could be introduced and maintained as a process in these systems whenever possible. The critical components of these ecosystems are strongly linked, indicating that fuel reduction work may be most effective when designed with the entire ecosystem in mind.

Fuel is masticated prior to a prescribed burn on a study plot in the Pringle Falls Experimental Forest. *Forest Service*

Lead: Pacific Northwest Research Station

Scientists Study the Effects of Harvesting Fire-Killed Trees

Findings help land managers fine tune their post-fire treatments to speed forest recovery process

Large areas of fire-killed trees are ready fuel when another fire occurs, so removing some large dead wood may reduce potential fuel load. The harvesting equipment used in post-fire logging disturbs forest soils, however, frequently results in soil compaction, soil pore size reduction, and decreases oxygen availability and water and nutrient movement to tree roots. The effects of this mechanical disturbance on soil productivity and forest recovery differ in terms of severity, the amount of time since the disturbance, and site factors. To alleviate compaction, the practice of subsoiling or deep tillage is used to fracture the lower soil strata—but a tradeoff exists—tillage may degrade soil structure and adversely affect microbial biomass and diversity. This short-term study was developed to fine tune post-fire treatments that shorten the forest recovery process. Scientists found that soil bacteria and fungi that are essential to mediating decomposition and nutrient cycling appear resilient to timber harvesting applications, but the process reduces the nutrients that are critical to soil productivity. This information will contribute to the success of recovery projects on fire sites in dry, mixed-conifer forests with volcanic soils.

A researcher collects soil samples from an area burned by wildfire on the Deschutes National Forest. *Forest Service*

Lead: Pacific Northwest Research Station

New Techniques Improve National Emissions Inventory for Wildland Fire

The U.S. Environmental Protection Agency is using new techniques to create the next national emissions inventory for wildland fire

The National Emissions Inventory of the U.S. Environmental Protection Agency (EPA) is a comprehensive estimate of emitted air pollutants. The inventory is prepared every 3 years and includes emissions from prescribed and wildfire wildland fires. This inventory forms the basis of regulatory modeling, policy decisions, State and Federal air-quality plans, and reports on global greenhouse gasses. Forest Service scientists worked with numerous stakeholders, including Federal agencies, regional planning organizations, State agencies, air-quality regulators, and the EPA, to significantly improve the national emissions inventory for wildland fire. The inventory now significantly improves overall estimates of fire size, fuel loading, fuel consumption, and emissions by using additional data sets and a new methodology for combining and reconciling disparate data sets into a unified data stream. The Forest Service's Fire and Aviation Management unit has expanded this effort to create a 10-year climatology of wildland fire (prescribed fire and wildfire). Development of additional techniques is being funded by a research grant from the Joint Fire Sciences Program.

Lead: Pacific Northwest Research Station

Pacific Fire Exchange Is the Hottest Partnership in the Pacific

A new collaboration promotes and uses the best available science to reduce wildfire management costs and improve land managers' ability to protect people and natural resources

Despite an urgent need for detailed, relevant, and accessible wildfire management information, the Pacific region lacks regionally specific fire-science information and technology. The Forest Service recently formed and funded the Pacific Fire Exchange to address the need for a regional, collaborative approach for effective fire prevention, mitigation, and management. Although initial efforts have made significant progress in understanding fire dynamics, ecological effects, and fuels mitigation in the Pacific region, a need is growing for additional region-specific fire research. The exchange, therefore, also exists to stimulate and promote use of "best available" research to reduce wildfire management costs and enhance land managers' ability to effectively protect natural, cultural, and community resources from wildfire devastation. To maximize the value of this next generation of fire science, effective communication, information exchange, and science delivery must be formalized and expanded so future research is guided by managers' needs and so knowledge and tools gained from the science are efficiently transferred to users who need them. The exchange is part of the national network of Joint Fire Science Program Knowledge Exchange Consortia.

Invasive grass fire in Hawaii. *Forest Service*

Lead: Pacific Southwest Research Station

Breaking the Grass-Fire Cycle in Dryland Ecosystems in Hawaii

Scientists develop practical tools to manage and restore tropical dry forest landscapes on military lands in the Pacific

Tropical dry forest landscapes on military lands in the Pacific region are declining at alarming rates, largely a result of fire that originates with the invasion of native ecosystems by fire-prone invasive grasses and shrubs. These novel fire regimes have serious impacts on cultural and natural resources and on the health and safety of the region's citizens. Forest Service scientists believe that using science-based tools developed to strategically inform natural resource management may be the most cost-effective approach to protecting and restoring native biodiversity and to reducing fuel loads, fire danger, and fire impacts while also controlling invasive species establishment and spread. Scientists combined newly developed, remotely sensed information with field-based studies on the Island of Hawaii to (1) define the current condition of and historical changes to tropical dry forests, (2) develop technology for restoration planning and ecosystem monitoring, (3) quantify restoration potential and develop restoration prescriptions for remnant dryland ecosystems, and (4) develop effective fire risk-reduction measures that protect forest fragments and initiate succession of degraded grasslands into native woody communities. Remotely sensed data have provided insights on historical dryland communities; aerial photography analysis has indicated forest change over time; high-resolution ecosystem mapping has informed natural resource management planning efforts; and near real-time Web-based satellite monitoring has provided land managers an effective tool for evaluating fire danger. Field-based methods address the potential for restoring native species to alter ecosystem structure to reduce fuel loads and fire danger, the major barriers to restoration across remnant native community types, and to test the effectiveness of a firebreak design that incorporates traditional fuel-breaks grading into "greenstrips" planted with fire-resistant native species. Results from this project will benefit the military mission in the Pacific region by increasing capacity and knowledge to restore native forests, reduce wildfire, and enhance habitat for threatened and endangered species.

Dry forest restoration in Hawaii. *Forest Service*

Lead: Pacific Southwest Research Station

Wildfire Can Benefit Landscapes and Reduce Threats to Local Communities

Scientists determine that managing wildfire across large portions of Sierra Nevada forests may alleviate the current hazardous fuels problem that has resulted from a fire deficit

Forests in California are vulnerable to large, severe wildfires that have the potential to harm human communities, habitat for sensitive wildlife species, and water resources. Research to date in the Western United States indicates that fire size and severity have been increasing during the past several decades. On the four national forests in northwestern California, a Forest Service study assessed the trends and patterns in fire size and frequency from 1910 to 2008 with all fires greater than 98 acres, and the percentage of high-severity in fires from 1987 to 2008 with all fires greater than 988 acres. From 1910 to 2008, mean and maximum fire size and total area burned annually increased, but the scientists found no trend over time in the percentage of high-severity fire from 1987 to 2008. The percentage of high-severity fire in conifer-dominated forests was generally higher in areas dominated by smaller diameter trees than in areas with larger diameter trees. Years when larger fires with the greatest area burned were produced by regionwide lightning events and characterized by less winter and spring precipitation than during years dominated by smaller human-ignited fires. The overall percentage of high-severity fire was generally lower in years characterized by regionwide lightning events and appears to be quite similar to prefire suppression-era severity patterns—largely because the fires burned mostly under less-than-severe conditions. In contrast, large human-caused fires generally escape under severe conditions and result in greater proportion of high severity. Our results suggest that under conditions typical of widespread lightning-fire outbreaks, wildfires could be more extensively used by land managers to achieve ecological and management objectives in northwestern California.

Hayfork Bally looking out over part of the 2008 Miners Fire near Hayfork. *Forest Service*

Lead: Pacific Southwest Research Station

Wildfire in the United States: Future Trends and Potential

Climate models project warming and increased droughts this century in the continental United States, so wildfire is likely to increase accordingly

Wildfire is a major forest disturbance in the United States—one with remarkable environmental, social, and economic impacts. Future wildfire trends are mainly determined by variability and change in climate, which is projected to become warmer and drier this century in the continental United States. Researchers at the Forest Service's Center for Forest Disturbance Science projected trends in wildfire potential for the continental United States using dynamical regional climate change downscaling simulations provided by the North American Regional Climate Change Assessment Program. The projection indicates significant wildfire increases in the Southwest, Rocky Mountains, northern Great Plains, Southeast, and Pacific coast, the effects of which will be most pronounced in summer and autumn, mainly caused by future warming trends. Fire seasons will become longer in many areas. In addition, the researchers found that the presence of fire potential has been increasing across continental United States in recent decades. Projecting future wildfire trends is essential for land managers to develop plans and strategies for mitigation and adaptation. This research contributed to the Forest Service's project on synthesis of greenhouse gas and black carbon emissions from wildlands and to the project on climate change adaptation and mitigation management options. The Resources for the Future and the Forest Service Climate Change Resource Center reported the fire projection data and subsequent results. The results will be published in *Forest Ecology and Management*.

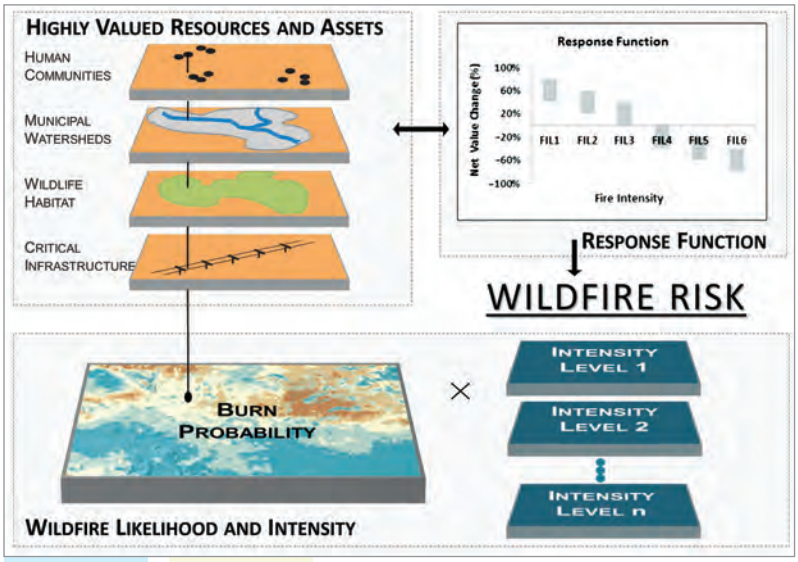
Climate is the most important environmental factor affecting long-term variability and change of wildfire. *R.C. Wilkinson, University of Florida*

Lead: Southern Research Station

Risk Analysis Prioritizes Investments in Hazardous Fuels Reduction

Scientists mitigate the adverse impacts of wildland fires

Wildfires can result in significant and adverse consequences to human health and safety, property, water quality, and to natural and cultural resources. The recent severe wildfire activity in Colorado and other Western States cements the saliency of these potential impacts and naturally leads to questions of how to best reduce wildfire risk. One of the primary ways land managers can mitigate the adverse impacts of wildland fires is by reducing hazardous fuel levels. Managers need methods to prioritize limited funding and resources for fuel treatments that need to be placed wisely on the landscape to cost effectively achieve management goals. Forest Service scientists developed useful information to prioritize investments in hazardous fuels reduction across forests throughout the region. The scientists led a series of workshops to identify the most important resources and assets that could potentially be impacted by wildfire. Coupled with estimates made for wildfire likelihood and intensity, scientists integrated this information into a wildfire risk-assessment framework to describe the variability in likely fire-related benefit and loss scenarios across the landscape. Scientists summarized results from the risk analysis for each ranger district and forest within the Rocky Mountain Region, with additional risk summarization for geographic areas where different types of fuel treatments are suitable. To streamline this process and help land managers assess risks on the lands they manage, the scientists developed a geospatial risk calculation toolbox. The toolbox is seamlessly integrated into a geographic information system, or GIS, known as the Esri ArcGIS environment, which is familiar to many resource managers and Forest Service GIS analysts. It would be ideal for this integration to lead to healthier landscapes, reduced losses and impacts to human communities, and reduced fire suppression costs for large fires. The risk-assessment methods applied in the analysis are consistent with the scientific underpinnings of the National Cohesive Wildland Fire Management Strategy and build off of existing risk-based tools, such as the Wildland Fire Decision Support System. The scientists helped implement the risk-assessment framework for a multitude of national forests throughout the Northern and Rocky Mountain Regions.



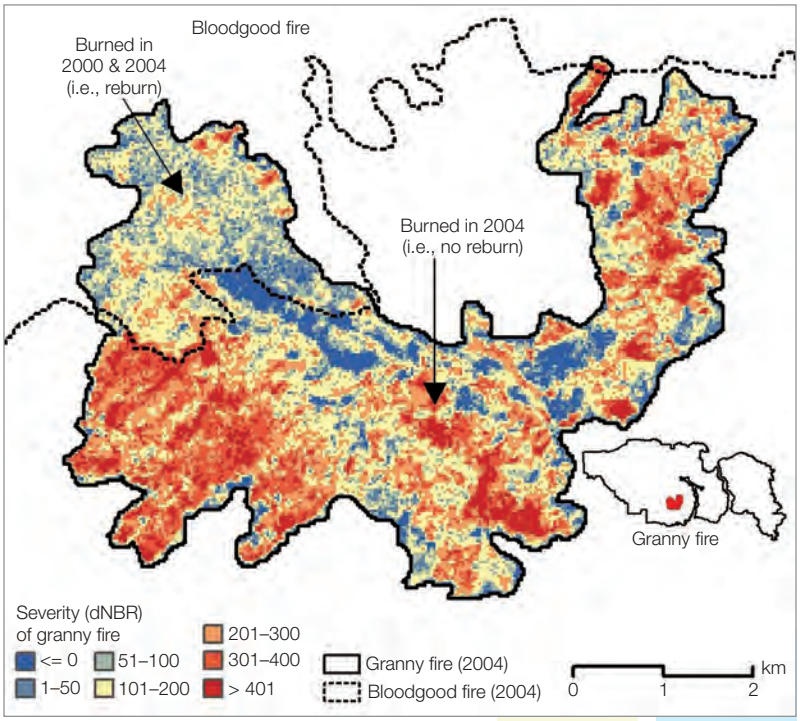
A spatial, quantitative wildfire risk assessment framework based on characterizing exposure of highly valued resources and assets to risk factors, as well as their response to varying levels of exposure. *Forest Service*

Lead: Rocky Mountain Research Station

The Effectiveness of Wildfire as a Fuel Treatment

New research results provide crucial information to land managers as they assess trade-offs associated with wildfire suppression and appropriate management response

Although wildland fires are not commonly thought of as a fuel treatment, fires consume fuel and alter vegetation structure, thereby having great potential to serve as fuel treatments in much the same way as more traditional means, such as mechanical or prescribed fire. The amount of land area treated by wildfire is expected to increase along with wildfire frequency associated with warming climates and recent revisions to Federal fire policy that enable the management of fire to attain multiple objectives. Thus, the need to understand the effectiveness of wildfire as a fuel treatment has never been greater, and new data will be critically important for developing appropriate management responses to future fire events. One purpose of traditional fuel treatments is to alter fuel condition so that future wildfires are less difficult, disruptive, and destructive. To investigate whether the burned area created by a wildfire treatment can temper or moderate the burn severity of a subsequent fire, scientists evaluated the effects of previous fires on subsequent burn severity for a large number of wildfires in two wilderness areas—Frank Church-River of No Return and Gila-Aldo Leopold—in the Western United States that have experienced substantial fire activity in recent decades. Results clearly show that wildfires moderate burn severity of subsequent wildfires in the two study areas, indicating that fire history has a substantial effect on burn severity. This moderating effect diminishes as the time between wildfire events becomes longer, but appears to persist for at least 22 years. These results provide crucial information to land managers to assess the trade-offs that are associated with wildfire suppression and in formulating an appropriate management response.



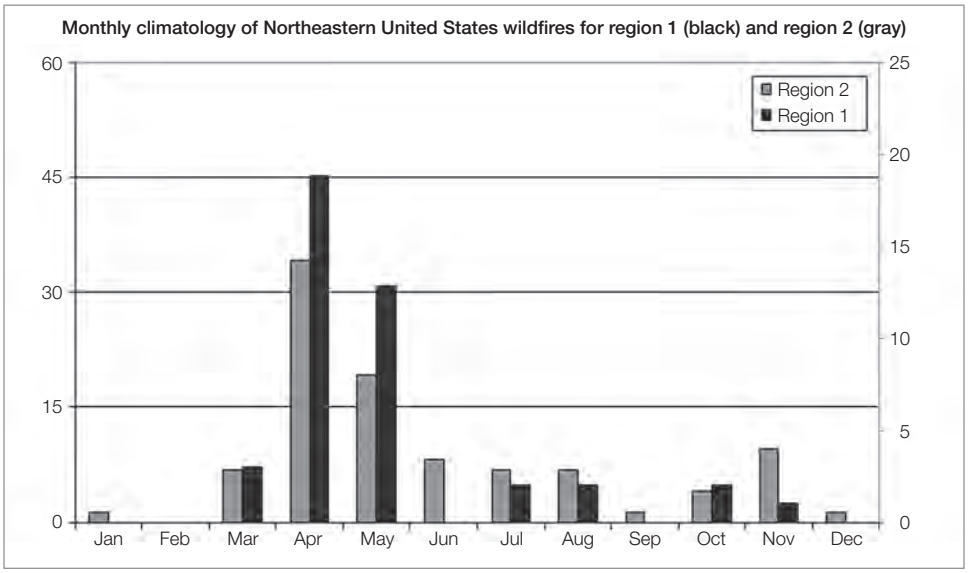
Burn severity for the Granny Fire (2004) in the Gila-Aldo Leopold Wilderness in New Mexico. Qualitatively, it appears as though areas that previously burned in 2000 had lower burn severity (i.e., dNBR) than areas that had not burned previously. *Forest Service*

Lead: Rocky Mountain Research Station

Scientists Develop Wildfire Weather Climatology for the Northeastern United States

Knowing where and why large wildfires have occurred in the past can help weather forecasters and fire managers predict future events with greater accuracy

Although large wildfires are less common in the Northeastern United States than in other parts of the country, they can still have substantial societal impacts due to high population density and the difficulty in accurately forecasting their occurrence. Forest Service scientists have developed a wildfire weather climatology that helps weather forecasters and fire managers assess where and why large wildfires have occurred in the past, so the onset of future wildfire events can be predicted with greater accuracy and confidence. A combination of densely populated locales and the inherent challenge of accurately forecasting rare events accentuate the difficulties that fire managers and fire weather forecasters face when managing large wildfires in the Northeast. The climatology divides the Northeast into two subregions: (1) the higher terrain of the Appalachian Mountains and (2) the coastal plain. The climatology establishes that nearly two-thirds of all large wildfires in the Northeast occur in April and May and that most fires in the region develop when the weather pattern is dominated by a high-pressure system. An analysis of the weather conditions during the events reveals the importance of dry air (low relative humidity) for many large wildfires in the region.



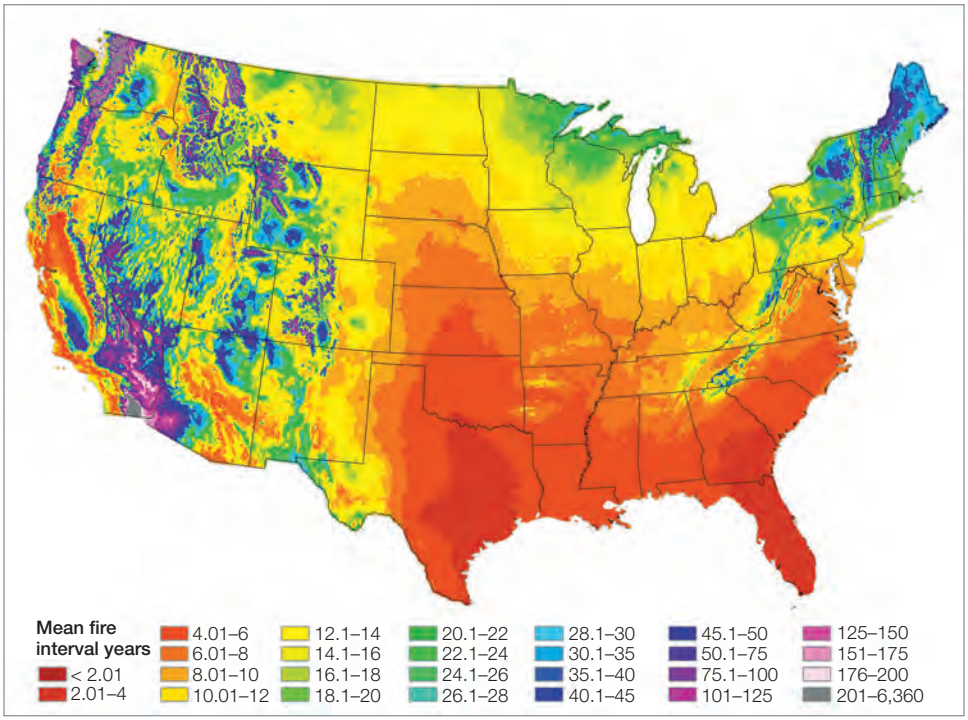
Monthly climatology of Northeastern United States wildfires for the Appalachian Mountains (region 1, black) and the coastal plain (region 2, gray). *Forest Service*

Lead: Northern Research Station

New Model Estimates Historic Fire Frequency

Model will help restore fire-dependent ecosystems and assess effects of changing climates

Knowledge of historic fire frequency is important in guiding restoration of fire-dependent ecosystems, but it is often missing or cannot be determined locally because fire scar tree records are lacking. A Forest Service scientist and collaborators have developed a new model called PC2FM (physical fire frequency model) that predicts historic fire frequency for the continental United States. The model is based on the fundamental laws of physical chemistry that govern combustion and hence forest fires. The model was calibrated and validated with North American fire data from 170 sites that date before 1850 and the widespread industrial influences related to land use, fire suppression, and recent climate change that affect the occurrence of wildland fires. The model uses mean maximum temperature, precipitation, the interaction of temperature and precipitation, and estimated reactant concentrations to estimate mean fire intervals (MFI). Having science-based estimates of historic fire frequencies for specific project areas is a major advancement in ecosystem restoration. Another important use of the model is in assessing potential changes in climate (temperature and moisture) on the likelihood of wildland fires. The PC2FM model can be used to map large-scale historic fire frequency and assess climate effect on landscape-scale fire regimes.



Map of mean fire interval years in the United States. *Forest Service*

Lead: Northern Research Station

Best Management Practices for Community Wildfire Protection Plans

Bringing local solutions to wildland fire management

Community wildfire protection planning, or CWPP, has been considered one of the most successful tools for addressing wildfire fire management in the wildland-urban interface. Although many communities have created CWPPs, foresters estimate that less than 10 percent of the communities at risk from wildfire have plans in place. Best management practices gleaned from the 10 percent can make the CWPP process more effective and efficient for the remaining 90 percent. Initiating legislation provided little direction for what a CWPP process or product might look like, leaving wildland-urban interface community members and their potential partners with a number of questions about what a CWPP should include and what process should be followed. Case studies conducted by Forest Service social scientists and their university colleagues in 13 communities nationwide offered some guidance to communities seeking to create or revise a CWPP. The best management practices that emerged from talking to more than 130 people are a collection of lessons that empower communities and their partners to produce a plan that takes into account their social and ecological contexts in addressing local wildland fire issues and concerns. Best management practices highlight the importance of drawing on a community's capacity and necessary networks while creating new capacities for future action. The practices highlight the linkage between how a community frames the issue of wildland fire management and the scale selected for the CWPP. Finally, the best management practices suggest steps to sustain interest, participation, resources, and support for the CWPP.

Local leaders help ensure that the community wildfire protection planning makes a difference on the ground. *Forest Service*

Lead: Northern Research Station

Spruce Budworm Effects on Fire Risk and Vegetation in the Boundary Waters Canoe Area Wilderness

Insect-killed trees do not necessarily increase fire risk

Insect disturbance is thought to increase fire risk by increasing dead fuels across large landscapes. Insect disturbances, however, also modify tree species composition and structure to influence fire disturbances across longer time scales. Forest Service scientists and their partners applied a landscape succession and disturbance model (LANDIS-II) to evaluate the relative strength of interactions among eastern spruce budworm (a native but destructive insect that feeds on the needles of fir and spruce), vegetation change, and fire disturbances in the Boundary Waters Canoe Area (BWCA) in northern Minnesota. They found that spruce budworm disturbance decreased area burned and fire severity when averaged across 300-year simulations. They concluded that budworm disturbance can partially mitigate long-term future fire risk by periodically reducing live ladder fuels within the mixed forest types of BWCA, although budworm disturbance will do little to reverse the compositional trends caused, in part, by fire suppression. These results have important ramifications for fire mitigation strategies and ecosystem restoration initiatives in the region.

Spruce and fir increase the vertical connectivity of live fuels, enhancing the potential for crown-fire activity. *Forest Service*

Lead: Northern Research Station

Wildfire Prevention Pays Big Dividends

Wildfire prevention efforts on tribal lands in the United States have benefits that likely exceed costs by at least tenfold

Forest Service scientists partnered with their agency colleagues, scientists from the National Institute of Standards and Technology, and wildfire mitigation specialists from the Bureau of Indian Affairs, Bureau of Land Management, and the States of Florida and Utah to analyze how wildfire prevention education and other wildfire prevention efforts can lead to reduced human-caused wildfires. By comparing historical wildfire ignition rates with detailed data on wildfire prevention, and data from the Florida Forest Service, among other factors, the scientists were able to identify the effects of overall prevention efforts and the effects of individual prevention efforts on wildfire occurrences. Research showed that, for a small investment in prevention of $500,00 per year in the early 2000s, the State of Florida has saved more than $3 million in suppression expenditures and $12 million in losses of structures, timber, and economic disruptions. Funded primarily by the Joint Fire Science Program and the National Fire Plan, this research is the first to quantify how fire prevention efforts lead to statistically significant and economically important reductions in unwanted wildfires. This research has led to new insights into the types of actions that are most effective at reducing unwanted wildfires. The findings are being used to update existing wildfire management software that is used by the Bureau of Indian Affairs and other agencies.

Tribal firefighting team. *Forest Service*

Lead: Southern Research Station

Wildlife and Fish

The Wildlife and Fish Strategic Program Area relies on interdisciplinary research to inform policy initiatives affecting wildlife and fish habitats 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.

Photo credit: Michael Mengak, http://www.Bugwood.org

Conserving Martens, Sables, and Fishers

New book provides the first comprehensive synthesis of knowledge about these species in nearly 20 years

Throughout North America, Europe, and Asia, all nine species of martens, sables, and fishers face significant conservation concerns and management challenges, many of which are growing increasingly urgent. These semi-arboreal forest carnivores contribute to the functioning of healthy ecosystems (especially as predators), serve as indicators of structurally complex habitats, and provide economic benefits as furbearers. The conservation of these animal populations will depend largely on the application of scientifically sound and practical programs for habitat and population management and educating public behavior. To facilitate the development of such programs, wildlife biologists synthesized the current state of knowledge on the genus *Martes* and developed a reliable basis for organizing interdisciplinary knowledge and identifying key elements to communicate to wildlife biologists, resource managers, and policymakers. "Biology and Conservation of Martens, Sables, and Fishers: A New Synthesis" provides the first comprehensive synthesis of knowledge about these species in nearly 20 years.

Pine marten. Michael Mengak, http://www.Bugwood.org

Lead: Pacific Northwest Research Station

Trout Populations Benefit From Novel Model That Examines Fragmented Habitat

Research helps set priorities for restoring connectivity of stream networks

Loss of habitat connectivity in stream networks can create problems for the persistence of valuable populations of aquatic animals. Forest Service researchers used a spatially explicit, individual-based model of a stream network to examine habitat fragmentation effects on the persistence of trout population. The results provide a framework for, and illustrate the value of, prioritizing efforts to restore the connectivity of stream networks. Resource managers need tools to identify and prioritize actions. Although substantial resources are being spent on restoring connectivity of stream networks, it is clear that better priority setting would increase the efficiency of the effort. Using a spatially explicit model of a northwestern California watershed, the researchers established a framework to better understand the effects of barriers on fish populations and identify those barriers with the greatest effect on population size and persistence. The novel modeling approach has been used to address a variety of key management issues, including cumulative effects analysis, the effects of streamflow diversions on fish populations, prediction of habitat restoration outcomes, and the effects of water quality on fish populations.

Lead: Pacific Southwest Research Station

Monitoring Network Saves Wealth of Data on American Bird Populations

Network archives data sets to address future large-scale conservation issues

With increasing focus on global-scale environmental issues, scientists have an urgent need to address large-scale issues for land bird populations, such as life histories, migration patterns, and population trends, among others, that cannot be accomplished on the scale of individual projects. Forest Service scientists at the Pacific Southwest Research Station, known at PSW-A, have joined with other governmental agencies, organizations, and individuals in the Western Hemisphere to create the Landbird Monitoring Network of the Americas. This network is working to archive banding and census data and to bring together scientists and database experts from PSW-A, Avian Knowledge Network, Cornell Laboratory of Ornithology, PBRO Conservation Sciences, and Klamath Bird Observatory. The network is working to retrieve and archive the wealth of data that had previously been collected but not retained for use on a larger scale. The network has archived nearly 4 million records of capture and census data from 60 cooperators in North and South America. About 40 percent of those data are available online for researchers to access and query over Web-based applications. The network also works to increase communication among researchers through regular newsletters and its Web page and by promoting large-scale studies among multiple researchers.

Lead: Pacific Southwest Research Station

Echolocation Monitoring Models Bat Occupancy Near Wind Energy Facilities

Model could mitigate the effects of wind energy development on populations of migratory bats

Bird and bat fatalities at wind energy facilities are a common occurrence. Although changes in facility siting and turbine design have reduced bird deaths, bat activity and migration are still poorly understood and casualties remain high. The amount of bat activity depends on the time of year and a number of environmental conditions, such as wind direction and speed, air temperature, and moon phase. Forest Service scientists developed a new interactive tool that enables users to visualize how changes in the time of year and weather conditions affect the probability of bats being present near wind energy facilities. They used data from multiple echolocation detectors, at a site near Palm Springs, CA, to model weather conditions when bats were present at the site. Use of such models, when integrated into existing computer software in turbines, could optimize turbine mitigations and decrease the number of bats killed with minimal disruption to energy production.

Fatalities of migratory bats, many of which use low-frequency echolocation calls, have become a primary environmental concern associated with wind energy development. The scientists combined the results of continuous echolocation and meteorological monitoring to model conditions that explained presence of low-frequency bats at a wind energy facility in southern California. The scientists used a site-occupancy approach to model nightly bat presence while accounting for variation in detection probability among echolocation detector heights. Detectors at 22 and 52 meters had greater detection probabilities for the bats than detectors at 2 meters above ground. Bat presence also was associated with lower nightly wind speeds and higher temperatures. The scientists suggest that use of multiple environmental variables to predict bat presence could improve the efficiency of turbine operational mitigations over mitigations based solely on wind speed.

Hoary bats (Lasiurus cinereus) are the most frequent fatalities at wind energy facilities. *Forest Service*

Lead: Pacific Southwest Research Station

Do Insects Visit and Pollinate Tanoak Flowers?

The knowledge is key for informed conservation of the species

Tanoak flowers are highly susceptible to Sudden Oak Death but little is known about the basic ecology of the species. For example, are tanoak flowers insect- or wind-pollinated? Tanoak conservation requires an understanding of the basic ecological genetics of the species and their pollination biology, which influences the size of local genetic neighborhoods and thereby defines conservation priorities. In 2009, citizen scientist volunteers conducted floral observations at three different sites in the Midpeninsula Regional Open Space District lands in the Coast Range of California. They observed 148 insect visitors to tanoak flowers during 11.5 hours of observation in 65 observation periods. The data that were obtained show that insects visit tanoak flowers. This information, along with a parallel pollinator exclusion study conducted by the University of California at Berkeley, suggests that tanoak flowers are predominately insect pollinated, but that some level of wind pollination is likely. Sudden Oak Death is decimating tanoaks. The research reveals a diverse community of insects visiting tanoak flowers that may be dependent on tanoak as a food source; therefore, they are also at risk due to the loss of trees from Sudden Oak Death.

Lead: Pacific Southwest Research Station

Scientists Study Endangered Mexican Spotted Owl

Research provides information useful to managers charged with conserving and restoring Mexican spotted owls and their habitat

The Mexican spotted owl is a threatened species inhabiting canyons and forests in the Southwestern United States and Mexico and frequently occurs in older, thick forests with heavy fuels. Managers are charged with integrating the conservation of owl habitat with other objectives such as forest restoration, so they need information about the owl's habitat use and population characteristics. From 2002 through 2011, Forest Service scientists studied Mexican spotted owl demography in the Sacramento Mountains in south-central New Mexico. This mountain range is host to numerous resident owls that occupy a contiguous mixed-conifer forest, which contains substantial amounts of private land and numerous dwellings. As a consequence, this area presents significant challenges to managers trying to conserve owl habitat while reducing fire risk in the extensive wildland-urban interface. The study documents vital rates (territory occupancy, reproduction, and survival) of resident owls, owl diet and habitat use, abundance of small mammals that comprise the main prey of Mexican spotted owls, and microclimatic conditions in the areas occupied by spotted owls. Research findings help scientists estimate trends in owl abundance, territory occupancy, reproduction, and survival rates. It also allows them to evaluate the relative influences of weather, prey, and habitat on the owl. This study provides rigorous, science-based information that is useful to managers charged with conserving and restoring Mexican spotted owls and their habitat. It also allows managers to integrate conservation objectives with efforts to restore forests to sustainable conditions and manage fire risk in this area, especially in the wildland-urban interface.

Rocky Mountain Research Station researchers attach a color band to a captured and hooded Mexican spotted owl. *Forest Service*

Lead: Rocky Mountain Research Station

The Effects of Energy Development on Hawks and Golden Eagles Documented

Results from a new wildlife study help managers develop conservation measures for ferruginous hawks and golden eagles in areas being developed for energy production

From 2000 to 2006, the number of oil wells in Wyoming increased by 73 percent and the number of natural gas wells increased by 318 percent. Much of this development is on Federal lands including the Thunder Basin National Grassland. Wind power is also developing rapidly. Current energy development overlaps the habitats of ferruginous hawks and golden eagles in Wyoming. Given the reported sensitivities of both birds to human disturbance, an important management issue is how to mitigate potential effects from energy development, while conserving these prairie raptors. In 2009, Forest Service scientists initiated an integrated study on how ferruginous hawks respond to energy development. The Wyoming Game and Fish Department, in cooperation with Forest Service scientists, used airplanes and helicopters to survey for nesting ferruginous hawks and golden eagles in 100 townships randomly distributed across the Wyoming prairies. Surveys reflect a population of 1,894 nesting pairs of ferruginous hawks in Wyoming and 798 nesting pairs of golden eagles. Researchers also sampled hawk movements in energy developments by fitting male ferruginous hawks with global positioning system transmitters in five territories that are developed for oil and gas extraction and one territory with wind turbine operations. These data, plus detailed samples of prey abundance, document how ferruginous hawks forage in the presence of energy developments. The American public understands the need for domestic energy production, but they also value wildlife conservation. Results from this study will help managers of natural resources develop conservation measures for ferruginous hawks and golden eagles with habitats in areas being developed for energy production.

Ferruginous hawk fitted with a Global Positioning System transmitter to study movements relative to oil/gas and wind energy development. *Forest Service*

Lead: Rocky Mountain Research Station

Threats From Wind Energy Turbines Identified for Migrating Golden Eagles

National team studies movement ecology of eagles to understand behaviors that may put them at risk from energy development

Wind power is a fast-growing industry with important implications for energy policy and broad potential to affect some migratory wildlife. Golden eagles are a species known to be at risk from wind energy development and in some areas are killed in large numbers by turbines. At other sites, however, turbines kill few eagles; thus, something about the site of turbines affects the risk to eagles. A national team (including two Forest Service scientists) is examining causes of these site differences, with the hope of mitigating this problem. Golden eagles migrate in large numbers through the central Appalachian Mountain region. This research uses novel animal tracking systems to identify specific minute-by-minute flight decisions eagles make on their migration and the potential for those decisions to increase the risk to birds from wind energy development in this economically important region. The team uses high-frequency Global Positioning System-Global System for Mobile Communications telemetry systems to collect data at 30-second intervals, to understand the intimate details of how birds fly. Data collection in Eastern North America shows that (a) flight altitude of eagles is determined in part by the topography over which they are flying; (b) that use of a low-altitude orographic (deflected) lift is less efficient than use of a thermal-gliding strategy that also pushes birds relatively higher into the sky and reduces the risk to eagles; and (c) that with increasing wind speeds, eagles are flying at lower altitude than at lower winds. This work is being expanded to the California desert, where the team is working with the Bureau of Land Management to characterize and minimize risk to eagles from development of wind energy on public lands there. This project is in collaboration with biologists from the Rocky Mountain Research Station in Arizona and collaborators from State and Federal agencies nationwide.

White-tailed sea eagles flying near their nest at the wind facility on the island of Smøla, Norway. This facility has killed many eagles and dramatically impacted the dynamics of their population. *Forest Service*

Lead: Northern Research Station

Scientist Refines Models Relating River Flows to Fish Habitat and Population Dynamics

To generate robust preductions, models need to acknowledge the complex life histories of riverine and diadromous fishes

A Northern Research Station fish biologist studying salmon and trout found that models relating river flows to fish habitat and population dynamics need to acknowledge the complex life histories of riverine and diadromous fish and also need to integrate stage-specific effects on population dynamics. Rivers flowing into the North Atlantic Ocean, Eastern North America, and Northwestern Europe have a long history of being modified for human use. Faced with increasing demands for water and hydropower energy and with fisheries and other ecosystem services at risk, land managers desperately need sound science for informed decisionmaking. Forest Service scientists reviewed the state of science relating river flow regimes to fish populations and outlined a framework for moving forward. Scientists made the case that to generate robust predictions, models need to acknowledge the complex life histories of riverine fishes and also need to integrate stage-specific effects on population dynamics, including compensatory responses. Forest Service scientists also demonstrated that many existing models rely on tenuous relationships between fish and predicted suitable habitat under altered flows. Using long-term data on river flow and fish growth and survival, the scientists showed that these approaches could easily generate erroneous conclusions. They suggested that an adaptive management approach, in combination with a network of long-term study sites, could substantially increase our understanding and significantly advance the field.

Altantic salmon smolt, ready to migrate to the ocean. *Forest Service*

Lead: Northern Research Station

Avian Diversity in the Agroscapes of Nicaragua's Northern Highlands

Creating biological corridors to sustain biodiversity, while increasing revenue for local farmers

Nicaragua's highland forests are threatened by continual wood extraction and encroaching agriculture. The effects of forest loss and fragmentation on bird communities and local human populations remain relatively unknown. Forest Service scientists characterized bird colonies in agroforestry systems under five natural and agroforestry land use types to compare and evaluate local and regional avian biodiversity in natural and anthropic habitats to predict the consequences of habitat and biotic losses to regional livelihoods. The complexity of the landscape mosaic determines the extent of the benefits from organic farming and other agroforestry management practices. Nicaragua's rapidly expanding agricultural landscapes are composed of varied habitats that play an important role in the conservation of diverse species, including birds, a major indicator of biodiversity richness. Birds protect trees from insects that consume foliage, thereby increasing tree growth, and maintaining the integrity of natural and agroforestry ecosystems. At local and regional levels, agricultural landscapes, or agroscapes, provide refuge, nesting sites, and food sources for wildlife and contribute to the connectivity of remnant forest patches. Some habitats within the agricultural matrix—monocultures and extensive grazing and pasture lands—generate isolation effects that negatively affect highland forest biodiversity and ecosystem products. The northern highlands historically have been dominated by coffee cultivations scattered among patches of cloud forest, one of the most threatened ecosystems on our planet and one with the highest biodiversity recorded in the neotropics. Cloud forests usually develop on the saddles of mountains, where moisture introduced by settling clouds is more effectively retained. The scientists characterized and compared bird communities among five land use systems in the Department of Jinotega in northern Nicaragua to document those bird communities that are most important in maintaining a rich biodiversity as well as communities that are vital to agroforestry production and local revenue within the zone. Species richness and abundance were greater in coffee plantations and forest fallows, whereas disturbance-sensitive species were more abundant in secondary and riparian forest. Species and foraging guilds characteristic of closed-canopy forest were found in coffee plantations, but only at points near forest remnants. Research results determined the contribution of each land use type within natural forest and agroscapes in maintaining biodiversity, to improving the conservation and connectivity of forest patches, and to alert farmers and private reserve owners as to the best mix of natural and human-influenced habitats that safeguard resources while enhancing livelihoods.

Nicaraguan reporter films biodiversity project. *Forest Service*

Lead: International Institute of Tropical Forestry

Photographic Key Determines Age and Gender in Two *Thryothorus* Wrens From Nicaragua's Pacific Slope

A visual and metric aid to determining age and gender in tropical wrens

Forest Service scientists used meristics, or countable traits, plumage, and molt characteristics to derive an innovative photographic key for determining age and gender in two species of Neotropical wrens, *Thryothorus rufalbus* and *T. modestus*. The key is useful in determining age and gender, a daunting task throughout the species' range, but especially in the tropics, where few studies have been conducted. Knowing a bird's age is an essential component of long-term avian banding programs designed to track changes in the demographics of Nearctic-Neotropical migrants and permanent residents, while monitoring their population trends. Plumage characteristics can be used to determine the gender and, much less often, the age of sexually dichromatic species that exhibit markedly different sizes and colors based on gender. Avian sexual dichromatism is prominent in species with wide geographical ranges, and especially in those that undergo long-distance migration, whereas it is much less common in species with limited distribution and restricted movements. Neotropical wrens, which are members of the mostly New World family Troglodytidae, in general, tend to be sexually monochromatic (although seasonal sexual dichromatism occurs in some species). As a consequence, wrens pose a serious challenge to aging and sexing efforts. To investigate the best techniques to confidently age and sex 2 permanent-resident wrens, the scientists captured 92 Rufous-and-white wrens (*Thryothorus rufalbus*) and 61 Plain wrens (*T. modestus*). They discovered that the gradation in the hues of the eumelanin, or black, pigment in the feather barbs of both species was lighter in young birds and can be used with confidence in aging but should be used in combination with molt limits—the boundaries between replaced and retained wing feathers during molting. Wing chord length, in combination with plumage characters and brood patch, are reliable criteria for determining the sex of Rufous-and-white wrens.

Wildlife researcher demonstrating banding techniques for wren.
Forest Service

Lead: International Institute of Tropical Forestry

The Role of Millipedes in Tropical Ecosystems

The direct and indirect effects on litter of varying lignin content

Millipedes, which look like centipedes with an extra pair of legs on most of their body segments, are an essential part of tropical ecosystems for their role in decomposing vegetation and cycling nutrients back into the soil. Diplopods can influence decomposition directly by fragmenting leaf litter and indirectly by affecting microbial biomass. Forest Service scientists investigated the direct and indirect effects of millipedes on decomposition in a subtropical wet forest in Puerto Rico. They studied the influence of the substrate by using three leaf species with varying leaf mass and leaf area ratios and the effect millipede density has on the previously mentioned direct and indirect effects. The scientists found that the remaining leaf mass and leaf area were lowest in the species (*Dacryodes excelsa*) with the lowest leaf mass-to-leaf area ratio. Significantly less leaf mass was remaining from microcosms with the highest density of millipedes. Soil microbial biomass was significantly higher under *D. excelsa* leaves than for the other litter species, but microbial biomass did not significantly differ among the different millipede densities. They found that the effect of millipedes differed, depending on the lignin content of the litter species when the litter species were looked at separately, with the highest lignin-content leaf species (*Rourea surinamensis*) having significantly less leaf mass remaining with millipedes than without at the last collection. Litter species and the density of millipedes significantly affected soil pH. The research results show that millipedes have a direct effect on decomposition by fragmenting litter, and this effect depends on litter quality. The results also suggest that millipedes have little or no indirect effect in terms of influencing microbial biomass.

Millipedes used in the microcosms were all from the Order Stemmiulida, Family Stemmiulidae. *Forest Service*

Lead: International Institute of Tropical Forestry




Conversations With Conservation Leaders

Deborah Finch

Ariel Lugo

Michael Rains

Andrzej Bytnerowicz

A Conversation With Conservation Leader Deborah Finch

"Birds, Plants, and Big Vistas—Conservation in the Interior West"

When most people hear the words "Forest Service," they think of forests, but the agency also cares for vast spreads of rangelands and grasslands. Forest Service Program Manager Deborah Finch manages a large team of conservation and restoration scientists spread across seven research locations in the Interior West. After growing up in California, where she credits an inspiring science teacher and a nearby creek and orchards with sparking her interest in the outdoors, she left the State in her early 20s for summer job opportunities in Oregon and Wisconsin. She interned with the Rocky Mountain Research Station field laboratory in Arizona and was hired by the station when she completed her master's degree in zoology from Arizona State University in Tempe. She earned her Ph.D. in zoology and physiology from the University of Wyoming in Laramie, while working full time for the research station. Finch has lived and worked in New Mexico for the past 19 years. She runs the program from the agency's field laboratory in Albuquerque, where she focuses much of her research on riparian environments, specifically, evaluating the effects of wildland fire on those environments and how removing invasive woody plants and fuel loads to reduce the risk of fire will affect biological diversity and native and at-risk species. She is also interested in the restoration of grassland and shrubland ecosystems.

If one theme persists throughout her career and her personal life, it is her love of birds. She studies them, she watches them, and she works tirelessly in support of their appreciation and conservation. She is a founding member of "Partners in Flight," a combined private and public effort to conserve bird populations in North and South America. This same group recognized her achievements with a national award in 2006 for her scientific contributions to the field of land bird conservation, and she was recognized by the Forest Service's Wings Across the Americas program in 2012 for her bird studies in riparian ecosystems.

When you meet new people, how do you describe your job?
As a research scientist who specializes in ecology, ornithology, and wildlife biology for the Forest Service, I am also currently a manager of a large team of highly respected conservation and restoration scientists in the Interior West.

Is there an experience or moment that made you care enough about conservation to devote your career to it?
My high school science club and an inspiring biology teacher pointed me toward a career in the outdoors. The ecology courses I took as an undergraduate at California State universities continued to lead me to my passion in conservation ecology.

Where did you grow up, and what role did the surrounding natural environment play in your career?
I grew up in the suburbs of San Jose, CA. My nearby playground of Saratoga Creek influenced my long-term interest in riparian ecology, and the surrounding orchards of the Santa Clara valley, the towering redwoods of the coastal mountains, and the tidepools along the Pacific coast also influenced my love of the outdoors.

When you began your career, where did conservation fit into national priorities?
That was the time of *The Population Bomb* by Paul Ehrlich, a book that emphasized the need for reducing human population growth to prevent extinctions of species, and the founding of the Endangered Species Act of 1973. In the late 1980s, as I was finishing my Ph.D. in zoology and physiology, habitat fragmentation and old growth forests were huge topics. Many environmental groups had rising concerns about newly listed species such as the northern spotted owl, red-cockaded woodpecker, and Kirtland's warbler that were prominent on Forest Service land. As a result, new positions such as wildlife biologists and ecologists were created in the Forest Service and elsewhere and many of them were being filled by women.

Where do you think conservation fits into national priorities today. If there has been a shift, to what do you credit that shift?
Conservation remains very important in national priorities today, but concerns have shifted toward global concerns about climate change, invasive species, urban effects on wildlands, kids in the woods topics, and restoration. Within forested ecosystems, there are concerns about catastrophic wildfires and beetle kill.

What conservation issue do you think people are not talking about enough?
We need to talk more about invasive plant species and their control within the Forest Service and everywhere. Plants are the building blocks of habitats. Invasive species are the number one cause of habitat loss and species extinctions worldwide. They are also a leading cause of economic problems, ranging from problems in water systems and loss of commercial lands for farmers and ranchers, to problems for recreation and urban areas. Invasive plants also are associated with rapid fire spread. Many forest fires start in grasslands dominated by invasive plants like cheatgrass.

In the span of your career, what has been this Nation's greatest accomplishment in terms of conservation?
The Clean Air Act of 1970, the Clean Water Act of 1977, the Endangered Species Act of 1973, and the Pollution Prevention Act of 1990 are the Nation's greatest conservation accomplishments.

During the time between the pilgrims' arrival and today, what do you think has been the most devastating loss to America's natural resources?
The Dust Bowl of the 1930s was one of the worst calamities of our Nation's history and a wake-up call to manage rangelands and farmlands in the Great Plains better. The elimination of native tall grass prairies, the extermination of bison and predators, and the extinction of the passenger pigeon, a species whose flocks filled the skies, stand out as major regrets. The decline of other species that are now isolated into parks, such as grizzly bears and gray wolves, altered predator-prey relations, resulting in overabundance of many species. The accidental and deliberate introductions of many nonnative species have been especially devastating on many fronts, including damaging effects on native species, habitats, fire regimes, and human health and human activities such as agriculture, forestry, and fisheries.

What do you consider to be the "greatest save" for America's natural resources during that same time span?
In retrospect, after the catastrophic Dust Bowl of the 1930s, cattle stocking was reduced, farmers managed crops and water differently, and national grasslands were established; as a consequence, we were able to save or restore prairie ecosystems for agricultural use by people and protect remnants of the prairie ecosystems as public lands.

Do you believe such environmental catastrophes are behind us in this country?

I hope so. I do not think we'll have another Dust Bowl because we've learned some lessons. But today we understand that, ecologically, the world is all connected. Environmental influences do not stop at a State's or a country's boundaries. What happens in China can affect U.S. environments and visa versa. A paper recently published in *Nature* does a good job of laying out the potential consequences of human influence on a planetary scale. We know that local ecosystems can shift abruptly and irreversibly from one State to another when something forces them across critical thresholds (Volume 486: 52–58, 07 June 2012). The paper "Approaching a State Shift in Earth's Biosphere," discusses the plausibility of a planetary-scale "tipping point" and highlights the need to better detect early warning signs of a global, irreversible environmental shift. The paper warns if there is another mass extinction, it will most likely be human caused.

Is this what the "all lands" philosophy is all about?

Exactly. Just as lands are connected globally, they are connected across ownerships. We can no longer afford to consider public lands and private lands as distinct entities. An invasive plant species like cheatgrass is an obvious example. We can never hope to manage it, much less eradicate it, unless all stakeholders work in concert. The reason often given of how it acquired the name "cheatgrass" is because it cheated farmers of their crops and ranchers of desirable rangeland. It's also a big fire hazard and it pushes out native species. We may have a major breakthrough on our hands with something called "The Black Fingers of Death" pathogen. Susan Meyer, who works in the program at the Forest Service's shrub sciences lab in Provo, UT, is developing and testing strains of this pathogen. It attacks cheatgrass seeds, making them less viable. It could wind up being an effective tool to knock out or even just knock back this menace. If so, it would be a huge victory in the invasive species fight, economically and environmentally.

Do you even consider just throwing in the towel with invasive species? Just let nature run its course and see what happens?

Many species of nonnative plants and animals are unable to establish or spread, and nature runs its course before they are ever detected as problems. In other cases, the potential consequences to livelihoods and local economies, to the health of the land, and to native species would probably be so catastrophic that I believe we need to keep on fighting the good fight. Determining where and when to apply money and other resources to the land and developing tools for managing invasions and restoring sites are important goals of the Forest Service invasive species strategy. Landowners, public and private, need knowledge and tools to sustain healthy lands. Successful approaches to land management are underpinned by good science.

What do you want the Forest Service to achieve in the next 5 years? The next 50 years?

In the next 5 years, I would like to see us reverse our downsizing direction by aiming at the top priority issues of interest to the public and Congress and ensuring through press releases and integrated communication efforts that the public and Congress understand the priorities. For the Forest Service's Rocky Mountain Research Station, which the program belongs to, the priorities are research in fire, other major disturbances, water, endangered species, resilient landscapes, and humans in landscapes. In the next 50 years, I would like to see the media and natural resources organizations recognize the Forest Service as the leader in conservation.

Why do you believe this recognition has eluded the Forest Service to date?

The Forest Service is recognized as a true leader by other forestry organizations globally. Yet our goals, products, and stakeholders have changed over time. With these changes come opportunities that we can capitalize on. We need to convey a clear message about the services we provide, the products we deliver, our science that makes a difference, and who our customers now are. I think the Forest Service would benefit by reaching out to a broader range of customers, by increasing efforts to market its image, and by celebrating its achievements regularly in the media and with its stakeholders.

You recently began publishing a newsletter called "GSDUpdate." Is that a communication vehicle for the public?

The *GSDUpdate* is a periodic report produced by our science program with the aim to reach out to stakeholders and interested parties in natural resource agencies, universities, and nongovernment organizations and to communicate within the Forest Service about new science findings useful to resource professionals. Themes vary by issue and so far have highlighted work on invasive species, climate changes, environmental disturbances, ecosystem restoration and sustainability, and science and management interactions. I have been excited by the responses that we have received!

What is the greatest opportunity you see coming for conservation and what is the Forest Service's role in realizing that opportunity?

The greatest opportunity is in the next generation of conservation leaders. We are working actively to identify those individuals through special programs such as "Cultural Transformation" at the Forest Service level and "Adopt a Campus" at the research station level. Cultural transformation, an agencywide initiative, focuses on developing a workforce that is as diverse as our Nation's people, and "Adopt a Campus" is an outreach method the Rocky Mountain Research Station has initiated to advertise science positions to universities with diverse student populations. Forest Service conservation education programs like "Kids in the Woods" have been successful in reaching our children, captivating them with the magic of the outdoors. Our agency also engages youth from middle and elementary schools through the magazines, *Natural Inquirer* and the *Investi-gator*. I am truly proud of our agency's leadership in these endeavors.

How have you evolved over the course of your career? What do you think is the most important skill you have gained?

I have evolved from being a scientist mostly interested in bird ecology to a program manager interested in everything having to do with conservation and natural resources management. The most important skill I have gained is in influencing and leading people and teams forward in a united way in new directions of environmental research.

As in so many other areas, it seems as though it is getting more difficult for people with differing views on conservation to communicate. Do you think that dialogue on conservation issues is happening today; if not, what do you think it's going to take to make dialogue possible?

I think dialogue on conservation has improved since when I started my career. In the Forest Service today, for example, we have many more scientific disciplines than when I was first hired and a lot of diversity in viewpoint, but we all engage in a common mission—which requires talking together to achieve, resulting in less conflict. Among Government agencies and other organizations, collaborative projects focused on several common, cross-boundary themes—such as landscape restoration, global change, invasive species, and fire—exemplify the strength and achievements gained through interorganizational work.

Who are the people and groups you interact with the most outside of the Forest Service?

I interact with universities, agencies within the U.S. Department of the Interior—the Bureau of Land Management, U.S. Fish and Wildlife Service, and U.S. Geological Survey—and other Federal agencies, State agencies, and a wide range of nongovernment organizations. Examples of interactions include cooperative research projects, sponsorship of university students, engagement in professional societies, endangered species recovery teams, and service in interagency working groups and committees.

Why does the Forest Service need a R&D (Research and Development) organization?

This organization is needed because there is no other R&D organization that adequately serves the land base of national forests and grasslands and the mission of this nationwide agency. The multiuse mission of our R&D branch aligns with our agency's multiuse mission. In addition, the international community is served by a strong R&D organization focused on multiuse lands and landscapes whose issues are similar to those of our agency.

What is the proper mix of private and public lands?

The current mix is a good start. Including lands in the public domain that feature special environments, features, and species would be good additions to the mix. Adding lands that feature disappearing ecosystems, such as tall-grass prairie or wilderness, would benefit society by ensuring that these resources are not lost altogether. Acknowledging and accounting for private lands that serve a conservation purpose is also important. Lands that have lost value but can be restored through agency actions might be good candidates as public lands also.

Deborah Finch on Antelope Island, Utah, during the bison roundup. *Forest Service*

New Mexico is called "The Land of Enchantment." You've lived in the State 17 years. Is that how you'd describe it?

It's a State with vast open spaces and big vistas. I love that. New Mexico has everything from mountains and forests to prairies and deserts. We have river ecosystems and alpine meadows and excellent wildlife-watching opportunities. The land is dotted with fascinating archaeological and historical sites, all fun to explore. The city of Albuquerque celebrates the biggest hot-air balloon fiesta in the world. New Mexico has farming, ranching, tourism, and the special braid of Anglo, Native American, and Hispanic cultures. Our schools and universities serve the needs of diverse communities. The favorite food is chili and the favorite saying is red or green, in reference to which chili you want. (I prefer green.) I love it all.

If you were not a program manager for the Forest Service, what do you think you would be doing for a living?

Being a career scientist would be a first choice. When I was growing up, I envisioned that I loved to write stories and poems, so I can also see myself as a freelance writer. Another option I considered was working for a nongovernment organization like The Nature Conservancy or as a faculty member at a university.

Looking back over your career so far, what accomplishment are you most proud of?

I was recognized for my contributions to the field of land bird conservation research by Partners in Flight in 2006. This is an organization I helped start so it was a special honor for me. I have served as leader for the Southwestern Willow Flycatcher Recovery Team and have published conservation assessments on many other species. Another accomplishment I'm proud of is I competed for and was awarded funds for the Middle Rio Grande Ecosystem Management Research Unit, a research effort that has produced 272 publications since 1994. A subset of research from this unit recently received the Birds Across the Americas Award from the Forest Service. Last, I've managed and mentored a number of young scientists who will be the conservation leaders of tomorrow. It's a thrill to see them grow in their careers and make significant contributions in their fields.

How do you see your future?

Who knows what the future will bring once my husband and I retire? Family is very important to me, so my destination may vary depending on where family is, but I love New Mexico so I hope my family will be there! I will likely increase bird watching, wildflower searches, and other outdoor activities upon retirement, and I have several exotic travel destinations on my bucket list. I hope to stay active in conservation when I retire, perhaps through volunteer work or university affiliations.

Last, what is your favorite bird and why?

Although I do not have a favorite bird, the one I felt most exhilarated in seeing was the Resplendent Quetzal, a trogon species found in cloud forests of Southern Mexico and Central America. While on a sister forest mission in Mexico, I took a grueling all-day hike with burros to the top of the mountain of El Triunfo Biosphere Reserve in Chiapas, Mexico, where I was elated to finally see this mythical bird. Sacred to the Mayans and Aztecs, Quetzal means "precious" in Nahuatl. According to the Aztecs, pregnant women carried a jade stone and quetzal feather inside of them. Together these items would create the infant's face and status in the world.

Resplendent Quetzal. *http://www.thinkstockphotos.com*

A Conversation With Conservationist
Ariel Lugo

"Conservation on a Crowded Island"

Ariel Lugo, director of the Forest Service's International Institute of Tropical Forestry (IITF) in Puerto Rico, has worked with the agency since 1979. He was born and raised in Puerto Rico and earned his bachelor's and master's degrees in biology from the University of Puerto Rico. He holds a Ph.D. in plant ecology from the University of North Carolina at Chapel Hill. His first "serious" job was at the University of Florida in Gainesville. That was in the early 70s in the wake of the social upheaval of the 1960s. Lugo does not remember experiencing any discrimination in those days because of his ethnicity, but his age was another matter. At 26, he was among the youngest faculty members on campus, and he looked it. When he parked his motorcycle on campus, the campus cops were quick to yell at him: "Boy, you can't park it there—those spaces are for faculty members!" Although he had envisioned continuing his life as an academic, like his father who was a professor of botany, his career would take a different path.

What role did the surrounding natural environment in Puerto Rico play in your career?

I grew up in urban and rural Puerto Rico at a time when the landscape was agricultural, mostly sugar cane. I loved the countryside but playing sports was on my mind more than anything else. I spent most of my free time playing basketball, volleyball, softball, and track.

When did your love for science take root (forgive the pun)?

Dr. Graciela Candelas was one of my professors at the University of Puerto Rico who changed my attitude about science and turned me into a serious student. She also encouraged me to work under H.T. Odum, who was considered a genius. His outlook on ecological systems still influences me today.

When you began your career, where did the surrounding natural environment play in your career?

The beginning of my career as a university professor at the University of Florida coincided with the development of environmentalism and the first Earth Day celebration. My students did read Aldo Leopold as part of their wildlife courses and, through them, I was made aware of the land ethic of the conservation movement.

Have you always been a conservationist?

Pretty much. Islanders are by nature conservationists because we know we must survive within our island's limited natural resources. For example, Pacific Islanders developed land use schemes organized by the idea of land tenure that spanned from mountain to reef centuries before the modern concept of White Water to Blue Water emerged.

What do you learn as an islander that mainlanders may not know?

How land is managed and conserved is far more important than the percentage of private versus public lands. For conservation to really work, people must apply the conservation principles to every acre in the world. Right now, in spite of our progress in many areas, that is not happening. What is always lacking is enough sensible people to control the spoilers. That's where science comes in. Science can provide the validation needed to encourage or mandate the necessary conservation.

When did you decide to embark on a career in conservation?

While I was still a professor of ecology at the University of Florida, my students motivated me to join their effort in preserving the Oklawaha River by preventing the U.S. Army Corps of Engineers from converting the river and its floodplain into the Cross-Florida Barge Canal. While I was teaching them, they were teaching me. Through that project I was recommended to a famous naturalist who was an advisor to President Jimmy Carter. That's how I wound up working for the Council on Environmental Quality in the White House during the Carter administration. That job ended when Carter's presidency ended. When the council threw me a going away party, Forest Service Chief Max Peterson showed up. He had been one of my students at a 2-week intensive course in ecology that the Forest Service hired me to teach at Camp Oklawaha. I did not remember him because there had been a lot of Forest Service students, but he remembered me and reminded me that I had taught him ecology. He then welcomed me to the Forest Service as project leader of the Institute of Tropical Forestry in Puerto Rico.

Was that how you came to work for the Forest Service?

Yes. The fact that the Forest Service Chief made a point of showing up to welcome me really surprised me. I was flattered. I already had a good impression of the agency from my experience at Camp Oklawaha. Most of the Forest Service students were foresters by training—deep timber people from the

Ariel Lugo and a Magnolia tree. *Forest Service*

South—and the emerging science of ecology, where components of a landscape such as trees, soil, and wildlife are considered in relation to each other, was a new way of thinking about land management. I had no idea how they'd react to me or what I was teaching. Occasionally the timber specialists clashed philosophically with the wildlife specialists who also attended. Nothing's changed; they still clash today. But all of them were quiet, respectful, and just listened intently to the instruction. I admired their professionalism and their willingness to keep learning. So my first impression of the Forest Service was very positive, and it still is today.

Did you ever work for the Government of Puerto Rico?

In 1972, I took a sabbatical from the University of Florida and went to Puerto Rico. The first Secretary of the Department of Natural Resources in Puerto Rico, Dr. Cruz A. Matos, appointed me as the Assistant Secretary for Planning. I was not a planner, but Dr. Matos wanted a scientist to be in charge of the planners. We worked day and night to develop a department with a strong conservation outlook based on original research that we conducted ourselves. Two years later, I returned to the University of Florida, but my heart and my head were still in Puerto Rico. Helping to administer the natural resources of Puerto Rico was exciting work. I also wondered what would happen to the resources of the island if others did not have the same level of commitment that we did.

What were some of the biggest challenges you experienced as Assistant Secretary for Planning?

Puerto Rico was one big abandoned pasture when I returned. The island had been almost completely deforested to make room for sugar cane and cattle. My fellow conservationists and I predicted that the urban footprint would continue to grow, as well as the cropland, and, as a result, the deforestation process would continue until the forests were completely gone. No one predicted the agricultural land would decline but it did. The Puerto Rican Government decided to industrialize the island and import food. So the urban area went up and the agricultural land declined vastly. And, a lot of forest land came back. We never expected that! But the path we are on is not sustainable with hardly any agriculture. We used to grow 60 percent of our food right on the island; today, we import 85 percent of our food. If food and fuel prices go up, as they are expected to do so, then we must grow at least some of our own food, but where? I am working with others in government to plan a workshop to give the island some options for the future. There is also the economics of tourism, which is 5 to 7 percent of the island's economy. Other islands have a much bigger tourist economy. That needs to be part of the discussion.

Do you think Puerto Rico will one day be able to sustain itself?

We will always be dependent on the outside world, like most countries, but we can reduce that dependency if we make the commitment. I believe this is possible because the population is decreasing and the island's infrastructure is overdeveloped. We have an opportunity to redevelop ourselves without expanding our footprint on the island. My current research includes the Urban Long-Term Research Areas, or ULTRA, a program of the Forest Service and the National Science Foundation.

How does that research help Puerto Ricans attain more sustainability?

It helps by being more effective in its outcomes as the research is better focused on the reality of the modern city. Typical urban research usually involves tree inventories, census activities, water quality sampling, or socioeconomic studies all conducted by separate scientists at separate locations with separate questions. In 1972, using this model, I concluded it was impossible to marry social and natural sciences. With ULTRA, we are unleashing a new powerful force that will transform the way we do science and view the human nature dichotomy. More than 60 scientists, students, and collaborators designed a network of research sites and data-gathering procedures to study the city socioecologically. The scientists all worked in San Juan but most had never met each other. Before they could begin the project, they had to learn each other's technical languages because the same word can have different meanings in the social versus the natural sciences. The city model they ultimately developed is a heuristic, or evidence-based, model that will evolve into a variety of computer models that display future scenarios of city sustainability.

When did you start at IITF ?

In 1979, I became project leader of the Forest Service's Institute of Tropical Forestry in Rio Piedras, PR. That's the same job I hold today, because after the 1993 Rio Convention, the institute evolved into the International Institute of Tropical Forestry with an expanded mission and a director.

How do you describe what you do?

I simply say I am a scientist, a fact that immediately conveys a mental image to the person I'm talking to. If asked to elaborate, I mention that I am a Government scientist who studies tropical forests, such as rain forests. As director of IITF, what we've been doing for almost 75 years is trying to understand the functioning and products of a complicated

rainforest biodiversity, the water that goes into cities, the carbon storage, things we refer to as "ecosystem services." What we've learned is that while you are getting services and products out of the land, you have to leave the land in a better condition that when you acquired it. That's true for public or privately owned land. Otherwise it is not possible to sustain it for current and future generations. As scientists at IITF, we've been getting the background information to do sustainable land management so we can approach it with more effectiveness.

Does IITF still have the hemisphere's biggest library on tropical forestry?

Yes, and that library is central to our research. It was established at the outset of the institute in 1939. Today, the library is fully electronic. In the tropics, there is a lot of gray scientific literature that is not on the Internet, and it's not necessarily in English. We have scanned a lot of that into our archives and catalogued it by country. We have scientific literature on tropical forestry in countries that the countries themselves may not have in their own libraries. Young scientists that depend solely on the Internet as their source of information can get biased toward recent materials and miss the history.

How is that historical information used?

One example—we can use those records to reconstruct carbon storage and the species composition of a forest so we can assess the change that has occurred over time. The Forest Service is designed for long-term research like no other scientific organization. We have always been interconnected by sending scientists to other countries. As an agency, we have good record keeping. We've got memos from the 20s and 30s in our records. Our library is the sum of knowledge on tropical forestry. It allows us to bridge the time and space gaps in the scientific record by good synthesis. Our scientists write a lot of articles and do a lot of useful, relevant research. But none of the articles on their own are helpful for understanding the totality, so we are constantly mining our library and other libraries as well for a new or overlooked piece of information. Conducting synthesis is an ongoing process that never stops if we are to be useful to society. Because the world is constantly changing and the pace of change is increasing, land managers and conservationists are constantly facing new problems and environmental surprises. Synthesis of information helps you address our changing present and uncertain future.

Where do you think conservation fits into national priorities today? If there has been a shift, to what do you credit that shift?

Today, conservation has come of age and permeates all natural resources management activities. The passage of NEPA (National Environmental Policy Act) and other conservation legislation, such as the Endangered Species Act, formalized and institutionalized conservation activities in Government agencies and allowed the public to engage agencies in conservation actions.

What conservation issue do you think people are not talking about enough?

The conservation of novelty and the conservation of darkness are not talked about sufficiently today. Novelty is nature's way of adapting to change by forming novel ecosystems. Conservation traditionally focuses on the pristine conditions and pristine systems, thus ignoring new conditions and new ecosystems. In addition, humans are lighting up the planet with night lights and, in the process, we are losing the values associated with darkness, such as being able to see the night sky in all of its beauty and magnificence. Moreover, organisms that depend on darkness to survive, such as many marine species, are affected by the glare of lights.

In the span of your career, what has been this Nation's greatest accomplishment in terms of conservation?

The recovery of certain species from virtual extinction such as the bald eagle, the alligator, the bison, and our own Puerto Rican Parrot, to name just a few.

During the time between the pilgrims' arrival and today, what do you think has been the most devastating loss to America's natural resources?

The loss of open spaces over which great numbers of species used to migrate. The USA is a country of vast open spaces, and each year these open spaces are fragmented and reduced little by little due to urban sprawl and construction of grey infrastructure.

What do you consider to be the "greatest save" for America's natural resources during that same timespan?

The establishment of national forests, national parks, and wildlife refuges that are all professionally managed is an unprecedented "save" not only for the USA but also for the world as a whole.

What do you want the IITF and the Forest Service as a whole to achieve in the next 5 years? The next 50 years?

Over the next 5 years, we need to take the conservation message to the city where most people live and become more objective towards natural phenomena when exercising conservation activities. Over the next 50 years, we need to fully embrace, understand, and conserve the notion of novelty in natural ecosystems. We should learn to recognize change as a natural outcome of the effects of natural and anthropogenic forces acting on the biota.

What is the greatest challenge you see coming for conservation, and how does the Forest Service, and IITF in particular, meet that challenge?

The greatest challenge is coping with environmental change and its biotic consequences and knowing when to accept or when to fight the changes. In the words of a famous song: "You've got to know when to hold 'em and know when to fold 'em." The song applies best to dealings with introduced species and in restoration activities. With unlimited time and resources, you can eradicate any species and restore small areas of any ecosystem you may desire to restore. But time and resources are not unlimited, and one needs to wisely invest them according to the situation. So, there might be situations when it is best to accept novel natural systems on degraded sites or even introduced species performing natural roles than it is to waste time and resources in situations we cannot control. Time and resources to restore and deal with introduced species are best spent in situations where we have opportunities for success.

What is the greatest opportunity you see coming for conservation, and what is the Forest Service's role in realizing that opportunity?

Humans are conveniently concentrating in the cities where they can be reached much easier than in the past when the population was dispersed over space. The Forest Service has a huge opportunity to serve people where they live and to have a positive influence on the human environment where natural components of the landscape—the green infrastructure—can greatly enhance the quality of life. Only the Forest Service has the mission and capacity to manage the urban landscape for the benefit of people and the conservation of biodiversity.

Have you evolved over the course of your career? If so, what do you think is the most important skill you have gained?

I have become more knowledgeable of how ecosystems function and learned that conservation requires the combined efforts of the social and natural sciences. Learning the art of collaboration and listening to others is perhaps the most important skill that I've gained. As in so many areas, it seems as though it is getting more difficult for people with differing views on conservation to communicate.

Do you think that dialogue on conservation issues is happening today and, if not, what will it take to make that dialogue possible?

Conservation dialogue is helped by scientific, especially socioecological, understanding. The more we learn, the easier it is to reach agreements on how to conserve. With increasing human effects on natural systems, the ecological situation has become more complicated and scientific understanding is lagging behind the demands of conservation. Without adequate understanding, conservation groups must rely on opinions, which are often conflicting. More scientific knowledge is necessary to reduce conflicts and lead human activities to effec-tive conservation actions.

Who are the people or the groups you interact with the most outside of the Forest Service?

I interact with nongovernmental conservation groups, urban community leaders, university students and faculty, and other State and Federal agencies.

Ariel Lugo engaging with children in Puerto Rico about conservation. *Forest Service*

What is the special niche of R&D (Research and Development)?

No other agency conducts the depth and breadth of research in natural resources that the Forest Service does. We have got decades of data and findings from research across North America and beyond, and our body of work keeps growing. Other agencies tend to work in much shorter time frames and much smaller geographical spheres. For example, we sent a researcher down to the Brazilian Amazon to gain some understanding about the effects of logging in that environment. A couple of other agencies were also down there for a few years, and then they left. We're still there. That's typical. We are the only agency that keeps hanging out with the trees! There is only so much understanding you can gain about ecosystems in a 5- or 10-year timespan, which is just a blink of an eye for many species.

If you were not the director of the IITF for the Forest Service, what do you imagine you would be doing for a living?

I would be a university professor of ecology.

Any guesses about what the Ariel Lugo legacy to conservation will be?

Most of my legacy will likely be in two aspects of my conservation work. First the written legacy that I leave behind might be useful to future conservationists and, second, there will be a piece of me in the continued operations of the IITF, an organization dedicated to research and conservation in the tropics.

Before we close, do you care to share any personal or professional plans you may have for the future?

My plans are to continue writing about tropical forests, particularly those of Puerto Rico and the Caribbean. Through my writings, I share my experiences and knowledge with future readers.

A Conversation With Conservation Leader
Michael Rains

"Urban Forests: A National Call to Action"

If you spend any time at all with Michael T. Rains, you will learn that he feels honored to serve the American public and fortunate to work for the greatest organization in the world. His conviction is crystal clear. It is compelling too, because few people have had as comprehensive a tour of the Forest Service as Rains has had in the course of a career that spans more than 40 years. The Director of the Northern Research Station since 2006 and Acting Director of the Forest Products Lab since early 2012, Rains is a passionate advocate of the need to improve the stewardship of urban natural resources to better link environmental health with community well-being. His previous positions include Director of the Northeastern Research Station, Deputy Chief for State and Private Forestry, and Director of the Northeastern Area. He has held various positions across the country and in the Forest Service's national headquarters in program areas including timber management, watershed restoration, budget planning and development, and information systems and administration. In addition to being passionate about urban natural resource stewardship, Rains is serious about education—pursuing it and providing it. His own academic journey began at Humboldt State University in his home State of California, where he earned a Bachelor of Science in Forest Management and a Master of Science in Watershed Management degree. Since then he has earned a Master of Public Administration degree at Georgia State University in Atlanta, GA; he is a certified teacher in Secondary Education for the Commonwealth of Pennsylvania with content areas of general science, environmental science, and mathematics; and he is currently completing a Master of Education degree in professional and secondary education. In June 2012, Rains was among the recipients of one of the Nation's highest civil service awards—the Presidential Rank Award Program's Meritorious Executive Award.

When you meet new people, how do you describe your job?
Cab drivers ask me that all the time. I say: "You see those trees over there? I make them look good and stay healthy." The response almost always is: "Wow, that sounds like a great job." I tell them that it is, and that I work for the greatest organization in the world, the Forest Service.

Is there an experience or moment that made you care enough about conservation to devote your career to it?
No, not really. My mother was a personnel clerk for the El Dorado National Forest in Placerville, CA. She always talked about the Forest Service in such glowing terms, including the forest supervisor, Irwin Bosworth (former Forest Service Chief Dale Bosworth's father). So, I got a job with the California Department of Forestry as a firefighter when I was 17 at Mt. Danaher in Camino, CA, and that changed everything for me. The next summer, I got a seasonal appointment on a logging road engineering crew on the El Dorado National Forest, and that's when I decided to go on to college and study forestry.

Where did you grow up, and what role did the surrounding natural environment play in your career?
I grew up in the *Barrios* of East Los Angeles. My father, a Great Depression-era fellow, headed west from Bible Hill, TN, in search of anything better. He settled in Bakersfield, CA, and then made his way to Los Angeles. Actually, nothing about my early childhood played a role in my career. Later, in high school at Placerville, CA—that's what kind of shaped the calling; again the influence of my mother. Honestly, I grew up poor and the Forest Service meant a job; I did not know it would become a great job and a terrific career when I signed on.

Where do you think conservation fits into national priorities today. If there has been a shift, to what do you credit that shift?
Clearly, conservation today is much more mainstream, albeit it could be more relevant to safety, health, and education if we were a bit more proactive in our roles and letting people know who we are, and the difference we make in their daily lives. I think time deserves the credit. Over time, people have become more sophisticated about planet Earth and the importance of natural resources conservation along the rural to urban land gradient. And, we have had some terrific leaders in the Forest Service who have helped advance the conservation ethic. Having said this, I think the environmental movement and environmental literacy are behind us, at least for the time being. My sense is that safety and health have emerged as the dominant issues of the day, and we have not done a very elegant job in linking contemporary conservation to the core values people find crucial to their daily lives. We should address this, just a bit better. Think about it: there are over 850 million acres of forests in America, including 103 million acres of urban forests. The Forest Service has a direct *and* indirect role on about 80 percent of these lands. We are indeed the proverbial "Big Dog" on this stage. And, as the world's premier conservation agency with Tom Tidwell, "America's Chief Forester," at the helm, we can make so much of a difference in linking environmental health with community stability throughout the complex rural to urban land gradient. When you get down to it, much of this country's ability to manage natural resources rests with the Forest Service. I cannot tell you how cool it is to be a part of *that*.

Are Americans becoming more or less integrated with nature? It seems a lot of the younger generation just wants to spend quality time with their electronic gadgets.
I think we have become less and less integrated with nature. Most people do not see the outdoors, as we traditionally described it—more of a wild setting—as important or even needed. Now, I do find people wanting to walk along a tree-lined boulevard and enjoy the outdoors in that setting. Most people will never visit the national forests. But, more and more will walk the paths of Fairmount Park in Philadelphia, PA, or Central Park in New York City. One of the great outdoor venues of our time is a small setting in New York City called the "9/11 Memorial." We may not think of this as nature, but the "9/11 Memorial Forest" may just be the most popular forest in our country for some time. Go there and I promise you a strong connection with nature, the outdoors, and people.

What conservation issue do you think people are not talking about enough?
Urban natural resources stewardship, the care of the 100 million acres of urban forests. Recently, a blue-ribbon commission completed a landmark report titled, "Vibrant Cities and Urban Forests: A National Call to Action." This report stems from an idea that I advanced, along with Drew Becher (now President of the Pennsylvania Horticultural Society) and Deputy Chief Jim Hubbard. This is a wonderful guiding document produced by some of the best minds on urban stewardship in America. In essence, we could truly begin to "care for the land and serve (most) people, ***where they live***." And, as the premier conservation agency in the world, who better to lead this calling than the Forest Service with great help by a wide range of insightful partners?

Why does urban forestry matter to the Northern Research Station?

Well, our station serves about one-half of America and over 80 percent of these people live in urban areas. To "care for the land and serve people, ***where they live***" means we must have an aggressive program in science-based urban natural resources stewardship. To be relevant, we need to make a difference in the health of the trees people see every day.

In May 2012, you presented "key notions" that included "The Great Integrator…Linking Human Health with Environmental Health." Can you elaborate on that?

Sure. Our calling should be to serve people and help improve their lives. To do this, we have to think in terms of the physical and mental well-being, and the role of a healthy environment to enhance this well-being. Thus, for me, our "sweet spot" is public service that effectively links environmental health with people's lives—their community well-being. Otherwise, we risk conducting irrelevant studies and compiling and analyzing information that makes little difference. I think we call this "being ineffective," right?

What would you say to people who do not see urban forests as "real" forests?

Perhaps they simply do not know what they do not know. As I said, I am from an urban area. Urban forests—really a few trees in the *Barrios*—provided a sense of place and well-being; a shady spot to rest. Urban trees, as our Chief says, "…are the hardest working trees in America." Urban trees are capital assets that make our air clean, reduce utility bills, and increase property values. They offer homes to watchable wildlife, and having butterflies and frogs and birds and deer as part of an urban settings is invaluable to a young person who might one day be Chief of the Forest Service—a conservation leader. And, with over 100 million acres (103,000,006, when you count the most famous forest in the world—the "9/11 Memorial Forest"), we are not talking about an insignificant landscape. With 83.7 percent of Americans depending on us to help "make these forests look good and stay healthy," how could we not consider these urban trees, forests, and forests ecosystem as an integral part of our country's landscape?

Has your thinking about cities and urban forestry evolved since you first joined the Forest Service?

You bet. In my early days with the agency, I was a "rural forester." Unless a tree had "four logs" before the first knot, I did not consider it that valuable; I certainly did not think of trees in terms of being a capital asset, which today I firmly believe an urban tree represents. So, over time, I have come to believe that our highest calling in the agency is Urban Natural Resources Stewardship. Our current Chief, in my view, is a conservation leader for the urban forest. This sure helps to bring attention to the need. Until Urban Natural Resources Stewardship becomes a "Forest Service" strategic program area (versus an individual mission area program), however, our dominant conservation role and promise for this program direction will not be fully achieved.

Michael Rains speaking with Secretary of Agriculture Tom Vilsack. *Forest Service*

The other question is about the mission area—you called it the "R&D Organization." I firmly believe that the mission area designations of the Forest Service will be the demise of our ability to carry out effective contemporary conservation in the 21st century. The mission areas—NFS [National Forest System]; SPF [State and Private Forestry]; R&D—served us well in the beginning. Now, they are outdated and stand in the way of conservation leadership. They blunt our ability to band together, share resources, and avoid duplication to achieve our mission. Do we need Forest Service science? Absolutely.

How does Forest Service science benefit people?

Forest Service science touches almost everyone, every day, and makes land management decisions go from good to great. Forest Service research is creating the innovative science and technology required to "keep forests in forestry" in ways that reduce costs, create jobs, and sustain economic activity and forests for the future. From abundant water to clean air to better, safer houses; from helping to keep wooden bats in major league baseball to saving firefighter lives and researching self-sticking stamps for the mail—Forest Service science touches us all, all the time. New examples of Forest Service science include wood-based nanotechnology, renewable bioenergy, and energy-efficient, wood-based buildings and other structures.

As in so many other areas, it seems as though it is getting more difficult for people with differing views on conservation to communicate. Do you think that dialogue on conservation issues is happening today, and if not, what do you think it's going to take to make dialogue possible?

Clearly, we are a divided Nation on almost everything. But we must remember, we live in the greatest country on Earth, and the quality of our future existence depends on effective dialogue and compromise. Fundamentally, we must keep trying. The current tide will change, I know it will. And that will be a celebratory time indeed. Until then, we all must do what we can to help all understand that a healthy environment and healthy life go hand in hand.

How have you evolved over the course of your career? What do you think is the most important skill you have gained?

I often say lately, "I wish I could be the employee I am now, 20 years ago." I am much less parochial—I now think of the Forest Service *first*. I am still impatient, but less so I think. I say three things about work: I am glad to be employed; it is an honor to work for the U.S. Department of Agriculture; and, I work for the greatest organization in the world, the Forest Service. For me it has been a wonderful career and a terrific ride. My most important skill? I think I have improved my ability to influence, and the older I get, the more I realize how much I do not know.

When you go to Capitol Hill, what do lawmakers tell you about the Northern Research Station and the Forest Service that we should know about?

Honestly, we are not well known. Sure, there are some good relationships at certain levels. But, compared to many other agencies, we are simply not mainstream. We have a wonderful, vibrant story to tell—we just need to tell it. Like I always say, we need to "tell to sell." We do try hard, and I do not want to be too critical. I simply think we could be so much better with focus—our key points—and work more with those who *decide*. And, above all else, advance the corporation *first*.

If you were not the Director of the Northern Research Station/Acting Director of the Forest Product Lab, what do you think you would be doing for a living?

I always wanted to teach, but my dream job? I want to be an analyst for the New York Yankees. Maybe I could find the next Robinson Cano.

A Conversation With Conservation Leader
Andrzej Bytnerowicz

"Drink the Wild Air"

As a young chemist in his native Poland, Andrzej Bytnerowicz's aspirations went beyond the beer that he was asked to develop while working for the country's Institute of Fermentation Industry. After deciding "that wasn't my future," Bytnerowicz pursued a loftier goal—to study and find ways to mitigate the increase in air pollution from the Nation's heavy industry and power plants. He has been studying air-pollution effects on plants ever since, for the past 30 years.

While earning his doctorate in Natural Sciences from Silesian University in Poland, Bytnerowicz developed a protocol for evaluating environmental contamination using chemical analysis of Scots pine (Pinus sylvestris L.) needles. During his work at the Statewide Air Pollution Research Center of the University of California, Riverside, initially as a Fulbright scholar and later as a postdoctoral student and an assistant researcher, Bytnerowicz examined air-pollution (ozone, sulfur dioxide, and nitrogen oxides) effects on California agricultural crops. That's when he began work with former Forest Service scientist Paul Miller, the agency's Pacific Southwest Station's leader in air-pollution research and became interested in the evaluation of nitrogenous (N) air pollution and atmospheric dry deposition of N to California ecosystems. In the 1980s, he evaluated air-pollution status, as well as atmospheric dry deposition, of nitrogen and sulfur to chaparral, mixed conifer forest, and subalpine ecosystems of southern California mountains (San Gabriel and San Bernardino) and the Sierra Nevada. Since joining the Forest Service's Pacific Southwest Research Station in 1990, Bytnerowicz has been involved in various air-pollution-related projects in California and Central Europe. In California, his work is mostly focused on the development and implementation of methods for the evaluation of air pollution in remote mountain areas. In Central Europe, Bytnerowicz coordinated several projects aimed at understanding distribution and effects of ambient ozone and other air pollutants on local forests.

You have numerous air-quality monitoring stations in the Sierra Nevada and White Mountains. Why is it important to monitor air quality at high elevations?

Those measurements give us information about long-range transport of pollutants because they are less affected by local sources of pollution. For example, if you go to the top of White Mountain—at 14,252 feet in elevation—what we see is a plume of air coming from a long distance, primarily from the Pacific Ocean. We can evaluate effects of long-range transport from Asia over North America on ambient air quality of California.

Another aspect to examine is vertical transport—that's important in understanding how pollution moves in complex mountain terrain, how air masses move into valleys and mountain ridges. Present atmospheric and emission models are not precise enough for understanding this distribution and deposition. So, we approached this problem from a different perspective, from a receptor site. We put our samplers in various locations in the mountains, and we measure concentrations of pollutants and by using geostatistics, we develop maps of their distribution.

What types of data are collected at these monitoring stations?

These are simple diffusion devices where you have a sampler body where a membrane allows a steady flow of air into a collecting medium. The media coated with different chemicals will collect ammonia, nitric acid, nitrogen oxide, ozone, and sulfur dioxide. You then extract these with water or a weak carbonate solution to determine the concentrations of each pollutant. You can measure quite a spectrum of pollutants.

Where is the pollution coming from?

In the Sierra Nevada, the pollutants are coming from the San Francisco Bay Area, San Joaquin and Central Valleys, and the Los Angeles Basin. Ozone can be transported long distances. From our research and past literature, we have found increased ozone in the Western United States caused by ozone and ozone precursors from Asia. Although the current background in North America is about 30 to 40 parts per billion (ppb) of ozone in the air, 3–10 ppb of which can be attributed to effects from Asia. Ozone precursors, like nitrogen oxide and volatile organic compounds, can travel long distances, undergo photochemical reactions, and lead to the formation of ozone. Ozone is formed on the way to North America. That's why it's so important for air-pollution researchers to have international collaborations because it's not local. Air pollution does not consider any borders. In regards to nitrogen deposition, agriculture in California is a big factor. The emissions—ammonia and nitric acid—come from volatilization of fertilizers. Photochemical reactions producing smog also contribute to nitric acid pollution, however, and use of catalytic converters increases ammonia concentrations in the atmosphere.

What do these findings mean for the fate of our forests?

Some models say that background levels of ozone across the Northern Hemisphere are increasing, and by 2100, 50 percent of global forests will be affected by toxic effects of ozone. That is why long-term and long-scale monitoring and international collaboration are so important. At least we can send a signal to those responsible for air-quality standards and emissions that something wrong is happening in the forests. Nitrogen (N) deposition may be good in some situations where nitrogen acts as a fertilizer in the nitrogen-poor ecosystems. But on the other hand, excess of N in some ecosystems is not good and may negatively affect forest health, biodiversity, or water quality. Especially in combination with ozone, it may lead to drought stress in plants because nitrogen promotes growth of aboveground plants. Consequently, the plants need more water as leaves and stems grow, but the roots do not and are not able to provide enough water. Trees are getting less water due to the changing climate or densification of forest stands due to fire prevention measures. With the addition of ozone and nitrogen deposition, the trees' water deficit is even higher. Bark beetles can move into the weakened forest stands, massive dieback of trees takes place, and we can have potential problems with catastrophic fires. This is a piece of a larger puzzle, and air pollution needs to be included in that.

Ozone also affects the ability of forests to sequester carbon. That leads us to examine how forests are able to mitigate climate change. Forests are able to take in less CO_2 (carbon dioxide) when elevated levels of ozone are present.

What are some conservation issues that people should talk about, but are not?

I think in this country, we excessively use fossil fuels. We do not have to. Everything comes down to energy issues. Increasing the mileage of cars is a great step forward. Talking about alternative sources of energy, especially solar and wind, is very important, too. We need to prevent excessive energy use not only in cars, but also in our homes—like having better thermal insulation for instance. In Poland, for instance, almost immediately after the change to the free market system in 1990s, the country started to insulate old,

energy-inefficient buildings, and new home structures are built with energy efficiency in mind. We can do much better, in my opinion, in this country as well. I think all options of smart energy use and unnecessary loss need to be considered. Taking more steps would improve our environment and would increase our national security, because we would be much less dependent on oil from the Middle East and we would not have to drill off shore. We have enough options for energy independence, if we use it smartly.

What has been the most devastating loss to America's natural resources?

I see quite a devastation of landscape, especially with open-pit mining for coal, oil, or other resources. Clearcutting of forests in the Northwest was a clear example of what should never have happened. I worry about natural gas and fracking, because the technology has not been fully tested and can be potentially dangerous to our water resources.

What is the greatest challenge that the Forest Service faces and how will it meet this challenge?

I think our greatest challenge is coping with potential climate change effects and things related to it, such as dieback of forests and catastrophic bark beetle attacks. We first have to understand the science and understand what can be done to prevent or adapt to these changes. It's not easy because there is a lot of uncertainty about the future. There may be technological breakthroughs in the next 10 years that will change directions and our understanding of climate change. We will have to change our way of thinking with the changing environment and changing technology. For that, well-designed, long-term monitoring and research are needed.

What do you like most about your job?

I would say the challenges and complexity. I enjoy the collaboration with land management and Region 5 air-quality managers. They use our data and our suggestions on what should be done. We have good working relationships also with various land managers. In our 1999 study in the Sierra Nevada, we had 30 to 40 people from Forest Service management working with us for 4 to 5 months changing passive samplers on a network of about 90 remote sites. This year, we had a White Mountains study connected to a Sierra Nevada study looking at the transport of air pollution from the California Central Valley across the Sierra into the White Mountain using a grant that Region 5 received and our own Pacific Southwest Station funds.

What has been your proudest moment during your Forest Service career?

One would be my involvement with understanding the chemical environment in the Sierra Nevada. During the 1999 study on ozone in the Sierra Nevada, and in the Lake Tahoe Basin in 2002, 2010, and 2012, I was able to coordinate the work of various scientists and land managers in a very collegial, friendly atmosphere to address those environmental issues and understand what we see is important to forest health in our environment.

The other was my work in 1990 in Europe where we looked at ozone in the Carpathian Mountain Range. This mountain chain is two to three times larger than the Sierra Nevada and goes through seven or eight different countries. Back then, no one had a clue about ozone air pollution in the Carpathians although it was potentially an important factor affecting forest health. With the support of the USDA and Forest Service, we were able to start research collaborations with European countries and U.S. scientists. We were able to develop an understanding of the chemical environment for this mountain chain. This research is continuing and led to other international activities.

Andrej Bytnerowicz at the Kuronian Spit National park in Lithuania. *Algirdas Augustaitis, Aleksandras Stulginskis University*

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