

October 2010

FOREST SERVICE RESEARCH AND DEVELOPMENT

Improvements in
Delivery of Research
Results Can Help
Ensure That Benefits
of Research Are
Realized



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Why GAO Did This Study

In recent decades, managing the nation's public and private forests and rangelands has become increasingly complex, requiring a sound understanding of science and science-based tools to address these complexities. The Department of Agriculture's Forest Service maintains a research and development program (FS R&D) to help provide scientific information and tools. GAO was asked to examine (1) the scope of research and development carried out by FS R&D and some of its resulting accomplishments, (2) trends in resources used in performing FS R&D work and the effects of those trends on its research efforts and priorities, and (3) recent steps FS R&D has taken to improve its ability to fulfill its mission and challenges it faces in doing so. In conducting this review, GAO analyzed FS R&D funding data for fiscal years 2000 to 2009 and staffing data for fiscal years 2006 to 2009 and interviewed officials from FS R&D, other federal agencies, and nonfederal entities.

What GAO Recommends

GAO recommends that the Forest Service assess the effectiveness of recent steps FS R&D has taken to improve science delivery and take steps to ensure that individual performance assessments better balance the various types of science delivery activities. In commenting on a draft of this report, the Forest Service agreed with GAO's findings and recommendations.

View [GAO-11-12](#) or key components. For more information, contact Anu Mittal at (202) 512-3841 or mittala@gao.gov.

FOREST SERVICE RESEARCH AND DEVELOPMENT

Improvements in Delivery of Research Results Can Help Ensure That Benefits of Research Are Realized

What GAO Found

The scope of FS R&D's work spans a range of research organized into seven strategic program areas: invasive species; inventory and monitoring; outdoor recreation; resource management and use; water, air, and soils; wildland fire; and wildlife and fish. Using funds appropriated to it, as well as funds from authorized external sources such as universities and other federal agencies, FS R&D operates a system of research stations, which in turn oversee laboratories, experimental forests, and other research locations nationwide. According to end users of FS R&D's work, its accomplishments are many and varied, including the Forest Inventory and Analysis program, which provides long-term data on the nation's forests; efforts to identify and control invasive pests; and software applications to quantify the environmental benefits of urban forests. Nevertheless, end users also identified areas requiring additional attention by FS R&D, such as social science research to better understand human interaction with natural resources.

Overall, spending by FS R&D—using both its own appropriated funds and resources from external sources—remained relatively flat during fiscal years 2000 through 2009, with an average annual increase of 3.2 percent, or 0.8 percent when adjusted for inflation; funding from external sources represented a small but growing portion of the total. Trends in spending varied across research stations, with some experiencing increases and others decreases. In response to these trends, many stations reduced their staffing levels and increasingly sought support from external sources. While doing so has had advantages, it has changed the way FS R&D carries out its work and sets research priorities. For example, because external funding is often short term in nature, reliance on this funding may lead FS R&D to address more short-term research issues.

FS R&D has taken steps to improve its ability to fulfill its mission in several areas, including increasing its efforts to deliver knowledge and tools to end users and involving end users in setting research agendas; improving funding allocation processes; and increasing coordination with other federal research agencies. Despite these efforts, challenges persist, particularly in the area of science delivery—that is, how research results are communicated. While FS R&D has created a more formal system for science delivery at multiple levels within the agency, and several research stations have specific programs dedicated to science delivery, numerous officials and end users told GAO that FS R&D places greater emphasis on peer-reviewed journals as a means of science delivery than on other types of science delivery efforts, such as workshops, that are often more useful to end users. According to these officials, the performance assessment system for FS R&D researchers often reinforces this bias. Without improved delivery of research results, land managers and others may be unable to fully benefit from the agency's work. FS R&D officials also reported several challenges that impede their ability to conduct their day-to-day research, including computing and information technology, human capital, and other administrative issues.

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Abbreviations

FS R&D	Forest Service Research and Development
FIA	Forest Inventory and Analysis
USGS	U.S. Geological Survey

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United States Government Accountability Office
Washington, DC 20548

October 29, 2010

The Honorable Harry Reid
Majority Leader
United States Senate

Dear Senator Reid:

As our nation's population has expanded, demands on public and private forests and rangelands for production, recreation, and other uses have also intensified. At the same time, managing these lands has become more complex as multiple stresses—including insect and disease outbreaks, climate change, and intense wildland fires—alter forest structures and affect forest uses. Managing forest resources in the face of these demands and stresses highlights the importance of a sound understanding of the science underlying these phenomena and the need for science-based tools for addressing problems. The Department of Agriculture's Forest Service is the land management agency responsible for sustaining the health, diversity, and productivity of the nation's forests and grasslands to meet the needs of present and future generations. The Forest Service maintains a research and development program that helps the agency and a broad range of other constituents manage these challenges by providing science as a foundation for stewardship decisions.

Forest Service Research and Development (FS R&D)—one of three main Forest Service programs—has as its mission to develop and deliver knowledge and innovative technology to improve the health and use of the nation's forests and rangelands, both public and private.¹ In fulfilling this mission, FS R&D conducts basic research in a range of biological, physical, and social science fields and applies this knowledge to develop technologies and deliver science to federal and state land managers, industry, private landowners, and other entities. The dissemination of knowledge and innovative technologies—the second half of FS R&D's

¹The Forest Service's other main programs are the National Forest System and the State and Private Forestry program. The National Forest System manages the nation's 193 million acres of national forest and grassland, while State and Private Forestry is responsible for providing technical and financial assistance to states, tribes, communities, and private landowners. Some research and development activities are carried out by these programs, but the majority of such activities are carried out by FS R&D, whose work is the focus of this report.

mission—is often referred to by FS R&D staff as science delivery. FS R&D receives funds appropriated to it as well as funds from other authorized external sources, including universities and other federal agencies.

To gain a better understanding of FS R&D, you asked us to review the program, including its mission and structure, its research areas and resulting accomplishments, and its process for setting priorities. Accordingly, this report examines (1) the scope of research and development carried out by FS R&D and some of its resulting accomplishments, (2) trends in resources used in performing FS R&D work and the effects of those trends on the agency’s research efforts and priorities, and (3) recent steps FS R&D has taken to improve its ability to fulfill its mission and the challenges it faces in doing so.

To do our work, we reviewed relevant laws, regulations, guidance, strategic plans, performance reviews, and historical documents and interviewed officials in FS R&D headquarters and all seven of the agency’s research stations. We also interviewed National Forest System and State and Private Forestry officials in all nine Forest Service regions, as well as stakeholders, including representatives from industry and other nonfederal groups, such as the National Association of University Forest Resources Programs, National Woodland Owners Association, and the National Association of State Foresters. We also interviewed officials from other federal agencies that conduct research similar to that of FS R&D, to determine the extent to which FS R&D coordinates its work with these other agencies to avoid duplication of research. We obtained and analyzed spending data for fiscal years 2000 through 2009 on funds appropriated for FS R&D and funds from other authorized sources,² as well as staffing data for fiscal years 2006 through 2009,³ for the program as a whole and at individual research stations. We analyzed the data in both nominal (actual) and real terms (adjusted for inflation).⁴ We assessed the reliability of funding and staffing data by reviewing the methods of data collection for relevant databases and determined that the data were sufficiently reliable

²For purposes of this report, we used outlay data—that is, data on obligations that have been, or are in the process of being, paid—to measure spending.

³We did not use staffing data for fiscal years 2000 through 2005 because the data contained coding errors that made them unreliable for our purposes.

⁴We adjusted nominal dollars using the gross domestic product price index, with 2009 as the base year. The purpose of showing dollars in inflation-adjusted terms is to permit comparisons of purchasing power.

for the purposes of this report. A more detailed description of our scope and methodology appears in appendix I.

We conducted this performance audit from October 2009 through October 2010, in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

Research has been a part of the Forest Service's mission since the agency's creation in 1905, and several Forest Service research facilities date back to the early 1900s. FS R&D's research and development activities take place within seven research stations (see fig. 1). Five of the seven are focused regionally, with each covering a multistate region; these are the Pacific Northwest, Pacific Southwest, Rocky Mountain, Northern, and Southern research stations. In contrast, the remaining two stations—the Forest Products Laboratory and the International Institute of Tropical Forestry⁵—are not regionally focused but, rather, concentrate on specific research topics.⁶ The stations are decentralized, with the director of each station reporting directly to the Chief of the Forest Service.

⁵In addition to its role as a research station under FS R&D, the International Institute of Tropical Forestry also manages activities within the Forest Service's State and Private Forestry and International Programs areas.

⁶Although the name "research station" is officially used only for the five geographically based stations, for purposes of this report, we refer to all seven of these entities—including the Forest Products Laboratory and the International Institute of Tropical Forestry—as research stations.

Figure 1: Geographical Coverage of FS R&D Research Stations



Source: GAO and Forest Service.

According to FS R&D officials, the geographic alignment of these stations helps foster understanding of, and focus research attention on, issues of local or regional significance. For example, large urban concentrations in the area covered by the Northern Research Station make urban forestry and social science a research priority. Within each of the five geographically based research stations, multiple laboratories carry out specific research activities. In addition, FS R&D maintains 81 experimental forests and ranges across the nation, which serve as sites for most of the agency's long-term research. These sites—which range in size from about 115 acres to over 55,000 acres—represent most of the nation's major forest ecosystems. With some sites dating back to the early 1900s, they have allowed FS R&D to compile long-term data about how forests respond to

changes in land use, climate, and various natural and human-caused disturbances. FS R&D's work is carried out by research scientists, technicians, and other professionals, using techniques from a diverse set of disciplines.

The mission of FS R&D is multifaceted. In developing and delivering knowledge and innovative technology, the agency is responsible both for long-term, basic research to increase scientific knowledge and for applied research and science delivery as a means of disseminating that knowledge to potential end users. In addition, FS R&D's mission includes the nation's forests and rangelands, both public and private. While much of FS R&D's role is to support the Forest Service in managing national forests, its research and science delivery activities are also to include issues related to forests and ranges on other federal lands, as well as nonfederal lands managed by states or private landowners.

In addition to funds appropriated to the Forest Service by Congress, FS R&D uses funds provided by external sources to conduct research and development and often collaborates with external entities in carrying out its work. FS R&D is authorized to do so by the Forest and Rangeland Renewable Resources Research Act of 1978⁷—the primary legislation authorizing FS R&D's activities—which states that, in implementing the act, FS R&D may cooperate with federal, state, and other governmental agencies; with public or private agencies, institutions, universities, and organizations; and with businesses and individuals in the United States and in other countries. The act allows the Secretary of Agriculture to receive money and other contributions from cooperators under such conditions as the Secretary may prescribe.

In addition to FS R&D, a number of other agencies focus on natural resource issues and may therefore also conduct research on forest issues. These agencies include, among others, the U.S. Geological Survey (USGS) within the Department of the Interior, the National Oceanic and Atmospheric Administration within the Department of Commerce, and the Environmental Protection Agency. Other agencies may also conduct forest-related research although their main focus is not on natural resource issues. For example, the National Aeronautics and Space Administration maintains an Earth science program intended to, among

⁷Pub.L. No. 95-307, as amended, 92 Stat. 353 (1978). This act repealed the McSweeney-McNary Forest Research Act of 1928, ch. 678, 45 Stat. 699-702, as amended.

other aims, improve the prediction of climate, weather, and natural hazards including wildland fire.

FS R&D's Work Encompasses a Wide Range of Research Activities and Has Resulted in Numerous Achievements over Time

The scope of FS R&D's work spans a range of research activities related to forests and rangelands, from collecting basic data on forest species to studying societal values in relation to land use. Agency officials and other stakeholders we spoke with attested to FS R&D's accomplishments over time, which run the gamut from basic data about the condition of the nation's forests to research and tools useful in managing wildland fire and invasive species, and also noted areas that could benefit from additional research.

FS R&D's Work Covers Multiple Research Areas, Both National and Regional in Scope

FS R&D's research addresses national and regional priorities, as well as areas of international concern. FS R&D disseminates the results of its research in many ways, including publication in peer-reviewed journals and other technical and general publications, creation of computer-based modeling tools, and workshops and other outreach activities. Through its funding allocation process, as well as central reviews of the stations' research agendas, FS R&D headquarters seeks to ensure that research activities are consistent with the agency's overall goals.

Research Areas and Locations

FS R&D's national and regional research aims have evolved over time to mirror shifts in the mission of the Forest Service as a whole. In the years after World War II, for example, the amount of timber harvested from national forests increased dramatically, and much of FS R&D's work focused on supporting management of the nation's forests for wood production and on the use of forest products. More recently, the Forest Service has emphasized maintaining and restoring land health, and, according to agency officials, FS R&D's emphasis has likewise shifted toward the functioning of whole ecosystems, including air and water quality, biological diversity, and climate change. This widening of research focus, according to FS R&D officials, encourages scientists and managers to work together across land ownership boundaries and support a landscape-scale approach to land management, which includes an

increased emphasis on urban forestry. FS R&D also conducts research in emerging areas such as climate change and nanotechnology.⁸

FS R&D's strategic plan provides goals to help the agency set priorities for its various research efforts and identify future program direction; this plan is linked to broader strategic plans both at the Forest Service and department level, as well as to plans developed by the research stations. According to agency planning documents, FS R&D has organized its research into the following seven "strategic program areas":

- *Invasive Species* provides 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 these species.
- *Inventory and Monitoring* provides resource data, analysis, and tools for identifying current status and trends of forests; management options and impacts, including modeling of forest conditions under various management scenarios; and threats from fire, insects, disease, and other natural processes.
- *Outdoor Recreation* develops 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.
- *Resource Management and Use* provides a scientific and technological base to sustainably manage and use forest resources and forest fiber-based products.
- *Water, Air and Soils* informs the sustainable management of these 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.
- *Wildland Fire* provides knowledge and tools to help reduce the negative impacts, and enhance the beneficial effects, of wildland fire on society and the environment.

⁸Nanotechnology is the ability to control matter at the scale of a nanometer, equal to one-billionth of a meter.

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- *Wildlife and Fish* informs policy initiatives affecting wildlife and fish habitat on private and public lands and the recovery of threatened or endangered species.

According to the agency, categorizing its research activities into these program areas has helped FS R&D report its accomplishments; plan research investments; organize areas of research for external peer review; improve agency accountability; and offer researchers more opportunity for interaction along broader, interdisciplinary topics.

According to agency officials, there are also five “emerging research areas” which cut across the seven strategic program areas and help the agency set research priorities. These emerging areas are (1) biomass and bioenergy, (2) climate change, (3) urban natural resources stewardship, (4) watershed management and restoration, and (5) nanotechnology. In addition to these emerging areas, the agency considers two long-standing programs to be “foundations” underpinning much of its research activities: the Forest Inventory and Analysis (FIA) program, a periodic census of the nation’s forest lands, and the network of 81 experimental forests and ranges the agency maintains.

FS R&D uses the strategic program areas to categorize its research nationwide, with each of the seven research stations also having a specific set of research programs based on regional priorities. For example, the Rocky Mountain Research Station has organized its work largely to reflect ecosystems and environments, with research areas covering forest and woodland ecosystems; grassland, shrubland, and desert ecosystems; wildlife and terrestrial ecosystems; and air, water, and aquatic environments. Station officials told us that organizing its research in this way reflects the interdisciplinary nature of the station’s research. In contrast, the Southern Research Station has several research areas devoted to issues of regional interest in the South, including southern pine ecology; insects, diseases, and invasive plants of southern forests; and restoring longleaf pine ecosystems. Appendix II lists the research programs and locations of all seven research stations.

According to FS R&D officials, research itself is generally carried out at individual laboratories maintained by the research stations, with the laboratories often focusing on specific research topics in a variety of settings. For example, among the Pacific Southwest Research Station’s laboratories are the Forest Fire Laboratory in southern California, which focuses on fire science, air quality, and recreation, and the Institute of Pacific Islands Forestry in Hawaii, which focuses on preserving and

restoring ecosystems throughout the Pacific islands. Likewise the Rocky Mountain Research Station conducts its research into grassland, shrubland, and desert ecosystems in laboratories located in diverse areas including Moscow, Idaho; Reno, Nevada; and Albuquerque, New Mexico. According to FS R&D officials and scientists, research carried out by the stations is often of broad interest. For example, the Southern Research Station's Forest Operations unit in Auburn, Alabama, conducts research on harvesting timber and other forest products, and all five geographically based research stations study wildland fire. Similarly, the two topically oriented research stations, the Forest Products Laboratory and the International Institute of Tropical Forestry, conduct research whose subject matter is of national or international interest not limited to any geographic area. For example, the Forest Products Laboratory studies wood preservatives, wood products such as plywood, techniques for using woody biomass, and other topics of nationwide interest, while the International Institute of Tropical Forestry examines issues, such as restoration of degraded tropical forests, of international interest.

Although some research is carried out solely by FS R&D researchers, it is also often done in collaboration with other entities, such as universities, nongovernmental organizations, or other federal research agencies. FS R&D officials and others we spoke with told us that such partnerships are valuable for several reasons. First, the partnerships are essential for FS R&D to carry out the full scope of its work because they allow the agency to take advantage of scientific expertise and facilities that it does not maintain on its own and that would be costly and potentially duplicative to develop. Second, by promoting interest and expertise outside FS R&D in certain issues, such relationships can stimulate partners to carry out additional research without FS R&D involvement—especially when additional research on a particular topic is needed but the agency does not have the resources necessary to continue. Finally, by working with other research entities and land management agencies, FS R&D can broaden the scope of its research to include a landscape-scale approach to land management issues. For example, the Tahoe Science Consortium was formed to promote science to help preserve, restore, and enhance the Lake Tahoe Basin in California and Nevada. It involves multiple research entities, including FS R&D, USGS, and the University of Nevada, Reno; land management agencies such as the Forest Service and the Department of the Interior; the state of Nevada; and others.

Science Delivery Activities

To disseminate the results of its work, FS R&D engages in multiple science delivery activities, including publishing its work both in peer-reviewed journals and in less technical media, such as handbooks, research station

newsletters, and Web sites. For example, FS R&D operates an online tool known as Treesearch, which allows users, including the general public, to identify and obtain FS R&D research publications. FS R&D also works directly with land managers, state and local government officials, and others to provide information about FS R&D's work and how it can be used to help make decisions related to land management and policy. It also develops computer models and other tools that can be used in day-to-day land management activities. According to agency officials, responsibility for science delivery varies across FS R&D. Some research stations have a unit dedicated to science delivery, such as the Northern Research Station's Northern Science, Technology, and Applied Results program, or NorthSTAR, while others do not. Regardless, individual researchers are still expected to take responsibility for some science delivery activities related to their research.

Managing FS R&D's Research Activities

The decentralized nature of the research stations, as well as the variety of work they conduct, increases the importance of central oversight of agency research to help ensure that research activities conducted at the stations align with the priorities of the agency as a whole. FS R&D officials told us they align research pursued at each research station with the agency's overall research agenda by requiring each of the station's research areas—generally known as research programs or research work units—to have a charter or research work unit description laying out its research plans and objectives. These charters and descriptions are centrally reviewed by FS R&D program officials to ensure consistency with the agency's research agenda. FS R&D officials also use the funding allocation process to ensure that priority research areas are addressed. FS R&D headquarters officials told us the agency has the flexibility to allocate funding among research stations and programs in response to changing and emerging needs because FS R&D's funding comes to the agency primarily through a single appropriation account, Forest and Rangeland Research, in contrast to the multiple accounts that were used in the past.⁹ In allocating funds to the research stations, the Forest Service's Research Executive Team—consisting of the FS R&D Deputy Chief, station

⁹Appropriations may also be accompanied by congressional committee direction to use a portion of the funds for specific issues. For example, the conference report accompanying the Department of the Interior, Environment, and Related Agencies Appropriations Act, 2010, directed FS R&D to, among other things, use \$800,000 of the agency's appropriation for the Center for Bottomlands Hardwood Research in Mississippi. (H.R. Conf. Rep. No. 111-316 at 132 (2009).) In general, committee report language is not legally binding, but agencies may decide to follow such language for practical reasons. See *Lincoln v. Vigil*, 508 U.S. 182, 193 (1993).

directors, and Washington office program directors—considers the priorities and goals outlined in the agency’s strategic plans as well as priorities identified by individual scientists and the research stations, making it both a top-down and a bottom-up process, according to one executive team official. By balancing emphasis on emerging needs at the national and regional levels with research needs identified by scientists in the field, this official explained, FS R&D remains nimble enough to respond to emerging issues while maintaining basic, long-term research.

Agency officials also told us that although FS R&D generally seeks to maintain year-to-year stability in its research and personnel, no FS R&D program or project is entitled to its previous year’s budget. In addition, while FS R&D headquarters allocates most funding directly to the research stations, it retains a small portion of funding to award the stations through a competitive process, under which stations compete for FS R&D funds to study current topics such as climate change. While these funds represent a small fraction of the stations’ overall budgets, the process encourages stations to prepare research proposals that demonstrate the extent to which their research agendas align with FS R&D’s overall research objectives. One research station director, for example, commented that forcing stations to compete for research dollars prevents the stations from simply continuing past funding and research practices and “doing the same thing we’ve done for 30 years.”

Stakeholders Identified Many and Varied FS R&D Accomplishments but Also Areas That Could Benefit from Additional Research

According to stakeholders we spoke with, including federal and state land managers, university researchers, and others, FS R&D’s accomplishments have been many and varied, and include efforts in both basic and applied research.¹⁰ Many of these same accomplishments were also identified by agency researchers and officials as being significant for FS R&D. Among the most frequently identified FS R&D accomplishments was the FIA program, as well as FS R&D’s work related to wildland fire, invasive species, and vegetation management. More broadly, many stakeholders cited FS R&D’s overall scientific credibility as a significant asset. Nevertheless, several stakeholders identified areas that, in their opinion, required greater attention by FS R&D.

¹⁰We relied on our interviews with stakeholders to identify FS R&D’s primary accomplishments and areas of research that may need greater attention. Appendix I lists the stakeholders interviewed.

Accomplishments

- *Forest Inventory and Analysis program.* One of the accomplishments most frequently identified was the FIA program, which has provided decades of data used to assess the status, trends, and sustainability of America's forests. To date, FIA data collection has been initiated for each state, most recently for Hawaii, Nevada, and Wyoming.¹¹ According to several stakeholders, these data have been fundamental to understanding the nature and changing condition of forest resources, which in turn has helped federal, state, and local governments, as well as others, make informed decisions about land use and management. A few stakeholders added that FIA data have been improving and are more useful today than in the recent past because they are more comprehensive and include state-specific summaries and interpretations, which helps, for example, state foresters better communicate the information to public officials, land managers, and the public at large. Several stakeholders told us that many state foresters relied on FIA data to prepare reports for State-Wide Assessments and Strategies for Forest Resources, required by the Food, Conservation, and Energy Act of 2008.¹² The assessments are designed to, among other things, identify the conditions and trends of forest resources in the state and threats to those resources.
- *Wildland fire.* FS R&D research has also led to a number of accomplishments in the area of wildland fire and fuel management, according to many stakeholders. Some Forest Service officials in National Forest System regional offices noted that FS R&D's research has helped them understand the role of fire, fire behavior, and how fire can be used as a management tool, including ways to effectively reintroduce fire into ecosystems from which it was excluded for many years. In addition, FS R&D has developed a number of tools that help land managers predict fire's effects on the landscape, such as potential paths a wildland fire might take, and thus support better decisions on wildland fire response, particularly in communities close to forests. FS R&D has also contributed key accomplishments in the area of smoke management and air quality. For example, one FS R&D official told us that in California, FS R&D work has facilitated forecasting the severity of smoke and effects on air quality due to wildland fire, allowing the California Air Resources Board to warn the public about air quality concerns.

¹¹The Agricultural Research, Extension, and Education Reform Act of 1998 mandated that the Forest Service partner with states and other groups to implement an annual inventory in all states and to develop a report for each state every 5 years.

¹²Pub. L. No. 110-234, § 8002, 122 Stat. 1280 (2008).

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- *Invasive species.* Invasive species, including nonnative plants and insects, have become one of the most significant environmental threats facing the nation's natural resources, costing the public more than \$138 billion per year in damage, loss, and control costs, according to FS R&D estimates. Several stakeholders told us that FS R&D work in this area has helped them identify ways to better manage infestations and assess potential or actual damage. For example, an exotic beetle from Asia called the emerald ash borer has, since its arrival in the United States in 2002, killed tens of millions of ash trees in a number of eastern and midwestern states and parts of Canada.¹³ FS R&D has done research into the beetle's life cycle, methods for detecting infestation, and the potential for using native enemies or pathogens to control the beetle biologically. Most significantly, according to one stakeholder, FS R&D developed a model that users, including state foresters, can apply to estimate the efforts and funding needed to most effectively attack this beetle. Some stakeholders also cited FS R&D's research into the mountain pine beetle, a native species that has caused significant tree mortality in the West recently, as another important accomplishment.
 - *Climate change.* FS R&D's climate change research is crucial in helping land managers plan for managing natural resources in the future, according to several stakeholders, who told us that because potential effects of climate change are complex and riddled with uncertainty, land managers are increasingly relying on researchers for new information and tools. One such tool cited by a stakeholder is the Template for Assessing Climate Change Impact and Management Options, a Web-based tool produced in part by FS R&D and intended to help land managers and planners integrate climate change science into land management planning.
 - *Vegetation management.* Several different types of accomplishments related to vegetation management and restoration were cited by stakeholders as important accomplishments. For example, scientists from the Southern Research Station, along with their research partners, have been contributing to restoration of the American chestnut.¹⁴ According to the American Chestnut Foundation and others, the American chestnut was

¹³For more information on the emerald ash borer, see GAO, *Invasive Forest Pests: Lessons Learned from Three Recent Infestations May Aid in Managing Future Efforts*, [GAO-06-353](#) (Washington, D.C.: Apr. 21, 2006).

¹⁴Other partners include the Southern Region of the National Forest System, the American Chestnut Foundation, and the University of Tennessee's Tree Improvement Program.

one of the most important trees in the eastern United States, once occupying about 25 percent of the hardwood canopy in eastern forests, but was virtually eliminated by a nonnative fungus called chestnut blight. FS R&D is contributing to the restoration effort by planting and monitoring plots of blight-resistant American chestnut seedlings.

- *Urban forestry.* FS R&D's efforts in urban forestry, including research on maintaining working forests within urbanizing landscapes and educating the public about the value of public and private forested lands to residents' quality of life, were also cited by some stakeholders as a major accomplishment of FS R&D. Among other efforts, FS R&D contributed to the development of a software application called i-Tree, which, according to the agency, can help urban communities quantify the benefits provided by community trees in mitigating pollution, managing storm water runoff, and other benefits and can be used to put a dollar value on street trees' annual environmental and aesthetic benefits.
- *Scientific credibility.* Beyond specific accomplishments, many stakeholders cited FS R&D's overall scientific credibility as a significant asset to the agency. Regardless of the topic, according to these stakeholders, FS R&D's work—which often rests on decades of research conducted by multiple scientists—is widely viewed as unbiased and scientifically rigorous, which lends weight to land management decisions based on that work. Several stakeholders in the Forest Service's National Forest System, for example, told us that FS R&D research was often useful in developing and defending complex or controversial agency land management decisions because it was generally viewed as being scientifically sound. Another stakeholder pointed out that 13 FS R&D scientists served on the Nobel Prize-winning Intergovernmental Panel on Climate Change, a mark of those scientists' proficiency in their fields.

Areas of Research Requiring Greater Attention

Along with accomplishments, stakeholders noted that improvements could be made in several areas—including FIA, wildland fire, and invasive species. They also noted the need for additional research into social sciences related to forest issues.

- Several stakeholders pointed out that FS R&D could improve FIA by adding increased specificity to the data collection efforts. They said that higher-resolution data collection in more locations, plus more frequent data collection, would help states make better-informed planning decisions. For example, one stakeholder suggested that more-detailed data could help spur job creation and economic development in the emerging alternative energy market by helping potential investors in biomass power

plants identify locations of sustainable supplies of woody biomass, which could then help determine the best places to build a new plant or expand an existing plant.

- Several stakeholders also cited a need for improvements to wildland fire and invasive species research. For example, several stakeholders noted that they would benefit from more assistance in applying the many tools FS R&D has developed to help land managers respond to wildland fire. Other stakeholders told us that increased FS R&D research into methods for controlling or eradicating invasive species—for example, the use of natural predators of invasive species—could help land managers better manage infestations.
- Several stakeholders told us the agency should focus more attention on social sciences. One stakeholder noted that increasing populations near forests has made it essential that land managers understand the impacts that changing recreation habits can potentially have on these forests. An FS R&D official observed that in addition to understanding the physical science of fire, managers must also understand how the public will react to different fire management choices, particularly where communities are directly affected by those choices.

Over the Last Decade, Spending by FS R&D Remained Relatively Flat, Affecting Its Hiring Patterns and Research Activities

Spending by FS R&D remained relatively flat during fiscal years 2000 through 2009, with a small but growing portion of the agency's total spending represented by funds received from external sources such as universities and other federal agencies. Trends in spending varied across the research stations, with some experiencing increases and others, decreases. These spending trends have affected FS R&D's hiring patterns and research activities.

Overall FS R&D Spending Remained Relatively Flat over the Last Decade, with an Increasing Proportion of Spending Coming from External Sources

Overall, the amount spent by FS R&D—using both Forest Service-appropriated funds as well as resources from external sources such as cooperating agencies and organizations—remained relatively flat during fiscal years 2000 through 2009, with funding from external sources representing a small but growing percentage of total spending.¹⁵ Total nominal spending increased from \$276.9 million in fiscal year 2000 to \$369.1 million in fiscal year 2009—an average annual increase of 3.2 percent. After adjusting these amounts for inflation, the average annual increase was 0.8 percent.

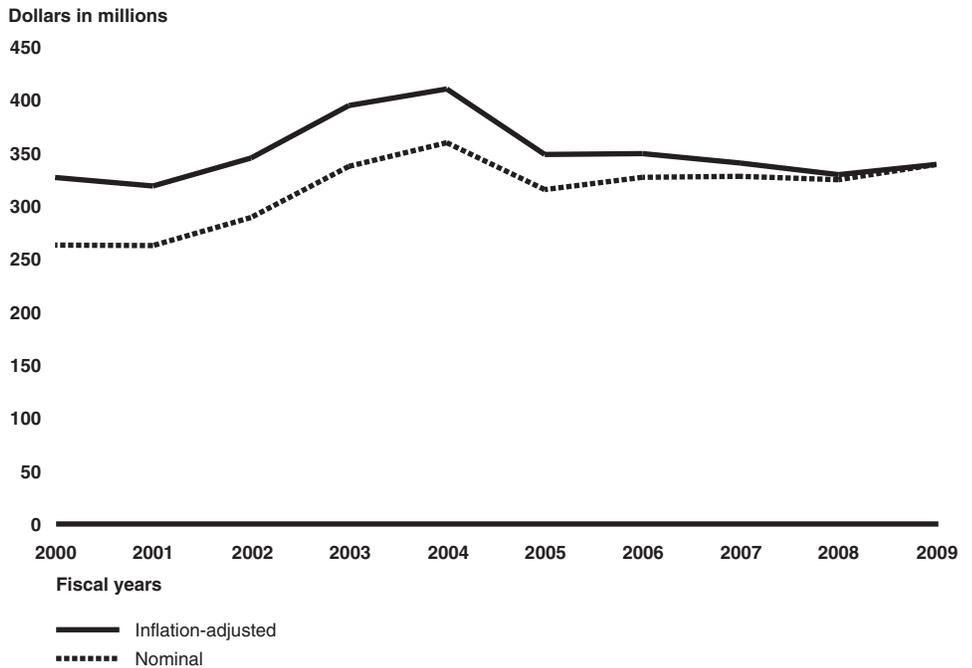
Spending Using Forest Service Appropriations

Resources spent using Forest Service appropriations, which constitute the majority of FS R&D spending, increased slightly in nominal terms but remained relatively flat in inflation-adjusted terms from fiscal year 2000 through fiscal year 2009 (see fig. 2).¹⁶ Spending increased from \$261.9 million in fiscal year 2000 to \$337.9 million in fiscal year 2009—an average annual increase of 2.9 percent. After these amounts were adjusted for inflation, the average annual increase was 0.4 percent.

¹⁵We measured the change in spending from fiscal years 2000 through 2009 using the compound annual rate of growth.

¹⁶This spending is primarily from the Forest and Rangeland Research appropriation account but also includes spending from other Forest Service accounts that support FS R&D activities, including Capital Improvement and Maintenance, and others.

Figure 2: Spending Using Forest Service Appropriations, Fiscal Years 2000 through 2009



Source: GAO analysis of Forest Service data.

Note: Spending is adjusted for inflation using 2009 dollars.

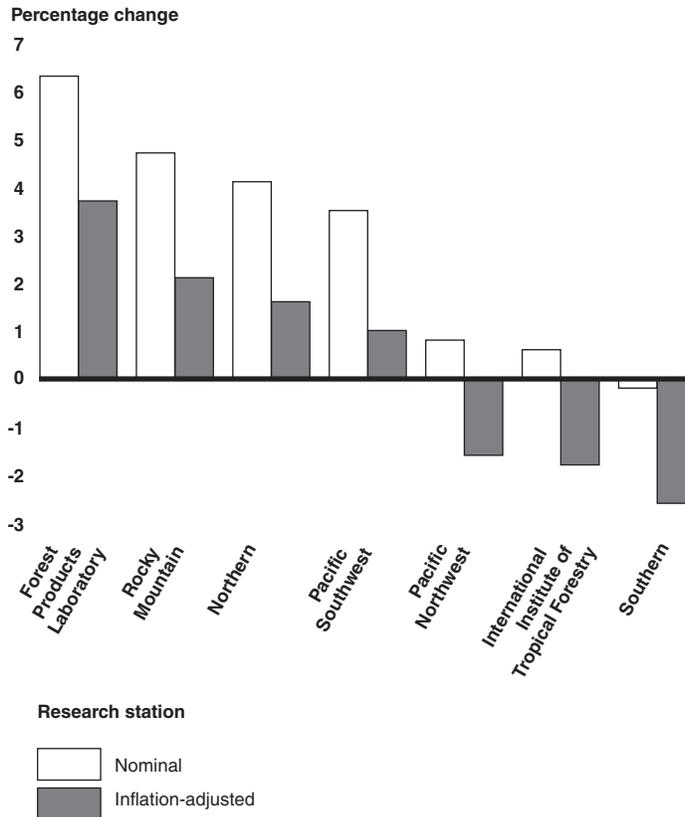
Spending may be increasing more quickly for FIA than for other types of research, however. Although FS R&D’s appropriation comes through a single appropriation account for “forest and rangeland research,” since fiscal year 2003 the annual appropriation has designated a portion of these funds for FIA, and FIA’s portion of this enacted budget authority has been growing at a faster rate than FS R&D appropriations as a whole. The enacted budget authority for FIA increased from \$31.7 million in fiscal year 2000 to \$60.8 million in fiscal year 2009—an average annual increase of 7.5 percent, or about 4.9 percent when adjusted for inflation. Although the remaining portion of the FS R&D budget authority increased from \$170 million to \$267 million during the same time, it grew only about half

as quickly, with an average annual increase of 2.6 percent when adjusted for inflation.¹⁷

Across the research stations, spending of Forest Service appropriations generally increased in nominal terms, with six of the seven stations showing an increase from fiscal year 2000 through fiscal year 2009. When adjusted for inflation, however, spending decreased at three stations: the International Institute of Tropical Forestry and the Pacific Northwest and Southern research stations. The Forest Products Laboratory, in contrast, experienced the most growth in spending over this time (see fig. 3). The amounts spent by each station varied from year to year, however, and even those stations that showed an overall decline in spending experienced some year-to-year increases during the decade. For example, although the Southern Research Station experienced an overall decrease in spending over the past decade, year-to-year spending showed an uneven pattern; after a sharp decline from fiscal year 2000 through fiscal year 2001, spending increased in each of the next 3 fiscal years before declining again (see app. III for more detail about year-to-year spending for each station).

¹⁷The enacted budget authority for forest and rangeland research in a given year does not necessarily equal FS R&D spending for that year, in part because the Forest Service has the ability to carry over forest and rangeland research funds from one fiscal year to spend them in other fiscal years and because FS R&D can spend from other Forest Service accounts that support research activities.

Figure 3: Average Annual Change in Research Station Spending Using Forest Service Appropriations, Fiscal Years 2000 through 2009



Source: GAO analysis of Forest Service data.

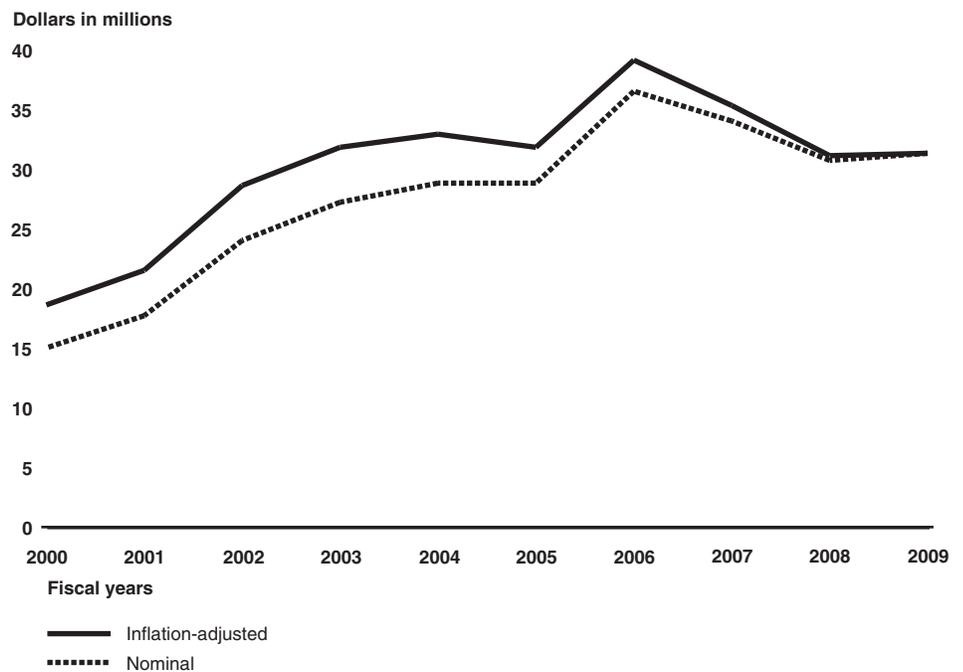
Note: Spending is adjusted for inflation using 2009 dollars.

Across the agency, personnel costs—that is, salaries and benefits—constituted the largest percentage of resources spent using Forest Service appropriations during this time, about 61 percent of spending, with yearly percentages varying from 58 percent to 67 percent. Across the research stations, the average percentage of resources spent on personnel costs varied from 50 percent at the International Institute of Tropical Forestry to 65 percent at the Northern Research Station. The second largest category of spending across FS R&D was grants and agreements, through which FS R&D provides funds for partners, such as universities, to conduct research. Spending on such grants and agreements increased from 14 percent of spending in fiscal year 2000 to 21 percent in fiscal year 2009—in line with FS R&D’s fiscal year 2012 goal (articulated in its 2008-2012 strategic plan) to devote 20 percent of its appropriated funds to such “extramural” research.

Spending Using External Sources

Although FS R&D spending using external sources of funding was much smaller than from FS R&D appropriations, spending from these sources increased at a faster pace over the last decade. Multiple organizations provide external support to FS R&D, including other federal agencies, states, industry, nonprofit organizations, universities, and others. Consistent with FS R&D's fiscal year 2012 goal (also contained in its 2008-2012 strategic plan) to obtain a portion of its funding from external sources, resources spent using external sources increased from \$15 million in fiscal year 2000 to \$31.3 million in fiscal year 2009—an average annual increase of 8.5 percent, or 6.0 percent after adjusting for inflation (see fig. 4). As a proportion of the FS R&D total, spending using external sources increased from 5.4 percent in fiscal year 2000 to 8.5 percent in fiscal year 2009. Officials told us that the amount of external funding the agency receives has depended on several factors, including the capacity of partners to provide funding and the ability of FS R&D scientists to successfully compete for such funding.

Figure 4: FS R&D Spending Using External Sources, Fiscal Years 2000 through 2009



Source: GAO analysis of Forest Service data.

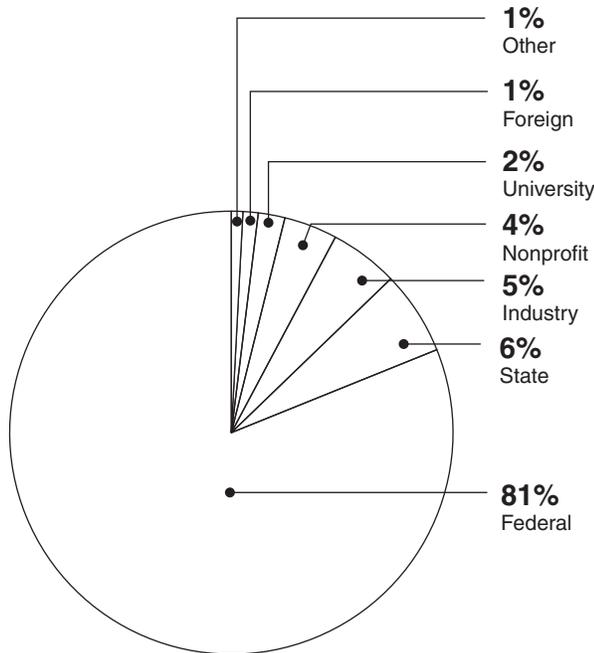
Note: Spending is adjusted for inflation using 2009 dollars.

Across the research stations, spending using external sources generally grew from fiscal year 2000 through fiscal year 2009, with average annual growth ranging from 0.5 percent at the Southern Research Station to 10.7 percent at the Northern Research Station, after adjusting for inflation. The exception to this trend was the Pacific Northwest Research Station, where spending using external sources declined 4.2 percent each year, on average, after adjusting for inflation. But these overall figures mask substantial year-to-year variation in the stations' spending of external funds. For example, at the Forest Products Laboratory, spending of external funds decreased about 35 percent from fiscal year 2006 to fiscal year 2007 but then increased more than 60 percent the following year (see app. III for more detail). Unlike spending using Forest Service appropriations, most funding from external sources was spent on grants and agreements, which increased from 22.9 percent of such spending in fiscal year 2000 to 55.3 percent in fiscal year 2009. The second-largest amount was spent on personnel costs, which decreased from about 32.5 percent in fiscal year 2000 to 21.7 percent in fiscal year 2009.

Regarding the sources of external funding, from fiscal years 2005 through 2009, the only period for which detailed data were available,¹⁸ the largest amounts of external support for FS R&D came from other federal agencies, followed by states and industry (see fig. 5). Support from other federal agencies increased from \$19.7 million in 2005 to \$24.2 million in 2009, or 2.7 percent after accounting for inflation. The Department of Defense and the Department of the Interior—both departments with land management responsibilities—provided FS R&D with the most support among the federal agencies. Support to FS R&D provided by some nonfederal sources, such as industry and universities, also increased over this time. In contrast, support from nonprofit organizations and states declined after accounting for inflation. Additional information about external funding also appears in appendix III.

¹⁸FS R&D moved to a new database in 2005, and data from the previous database were not available for fiscal years 2000 through 2004 at the same level of detail as for fiscal years 2005 through 2009.

Figure 5: FS R&D Sources of External Funding, by Percentage Contributed, Fiscal Years 2005 through 2009



Source: GAO analysis of Forest Service data.

Note: "Other" includes funding from cities, counties, tribes, local governments, and unidentified sources.

In addition to financial support, FS R&D has also received various forms of in-kind support from project collaborators, some of which have allowed FS R&D to share equipment, personnel, or computing capacity. For example, a number of FS R&D facilities have been co-located with universities, which has generally reduced the amount the agency needs to spend to rent a facility or purchase additional research equipment. In addition, the Northern and Pacific Northwest research stations have also used joint FS R&D and university faculty appointments to foster stronger relationships with significant collaborators and sources of in-kind support. At the Forest Products Laboratory, officials told us that industry partners have provided multiple types of in-kind support, including materials, such as wood chips or logs that the laboratory uses in its experiments.

Spending Trends Have Affected FS R&D's Hiring Patterns and Research Activities

Because a large percentage of each research station's budget is related to personnel costs, several stations have taken steps to reduce their staffing levels or change the type of employees they hire in response to the agency's flat spending trends. Officials at most research stations reported that when a permanent employee retires or leaves FS R&D, officials may not refill the vacant position with another permanent employee, instead leaving it vacant or filling the position with a temporary or term employee.¹⁹ Some research stations have gone further, offering buyouts to employees as a way to control personnel spending. FS R&D officials told us that replacing research scientists, in particular, requires a substantial commitment of resources because the combination of their salaries and the operating expenses associated with their research is higher than that of other staff positions. Several officials also told us that, in some cases, because of funding constraints, they did not refill some positions held by technicians—staff who typically conduct laboratory or field research work.

Our analysis of agency data shows that FS R&D spending on personnel has remained flat, and that the number of permanent employees at FS R&D has declined. From fiscal year 2006 through fiscal year 2009, the number of permanent FS R&D employees declined from 2,058 to 1,935—an average annual decrease of 2 percent (see table 1).²⁰ According to officials, at least part of this decline can be attributed to a reduction in administrative and clerical positions after the centralization of Forest Service business services beginning in 2005.²¹ The number of research scientists declined twice as fast as the overall number of permanent employees,²² from about 495 in fiscal year 2006 to about 437 in fiscal year 2009, an average annual decrease of 4.1 percent.²³

¹⁹Temporary employees are limited to working 6 months or less per year, while term employees are hired generally full-time for a period of 1 to 4 years.

²⁰Data before 2006 were not sufficiently reliable for our purposes and are therefore not included in our trend analysis.

²¹We are assessing this centralization effort and expect to issue a report in 2011.

²²Research scientists are those scientists reviewed under standard Office of Personnel Management criteria, known as a "research grade evaluation guide," every 3 to 5 years to determine grade classification and promotion.

²³As a result of our review, according to a senior official, FS R&D is verifying the number of research scientists to ensure that they are accurately reported. The figures we report come from a centralized database, which may slightly over- or undercount this category of scientists. FS R&D officials are currently comparing research station records with the centralized database to correct any inconsistencies.

Table 1: Number of Permanent FS R&D Employees, by Employment Type, Fiscal Years 2006 through 2009

Employment category	Fiscal years				Average annual change (percent)
	2006	2007	2008	2009	
Administrative	307	284	277	275	-3.6%
Blue collar	55	53	47	47	-5.1
Clerical	84	85	76	71	-5.5
Other	3	3	5	13	63.0
Professional ^a	1,209	1,208	1,165	1,140	-1.9
Technical	400	391	359	389	-0.9
Total	2,058	2,024	1,929	1,935	-2.0%

Source: GAO analysis of Forest Service data.

^aResearch scientists are included in the “Professional” category.

The decline in research scientists is part of a larger decline in the number of research scientists at FS R&D over the past several decades, as their numbers have decreased from approximately 1,000 in 1985. Term employees likewise declined during fiscal years 2006 through 2009, from 302 to 164, while the number of temporary employees fluctuated between 504 and 580 over that time. Across research stations, the number of permanent employees declined at five stations and remained relatively unchanged for the remaining two stations from fiscal years 2006 through 2009. (See app. III for more information about employment trends at the research stations.)

Some officials and scientists we spoke with were concerned that these staffing trends have reduced FS R&D’s capacity to conduct research because fewer permanent scientists and technicians remain to carry out the work; they were also worried about FS R&D’s ability to maintain its long-term research because of increased reliance on term and temporary employees. On the other hand, some FS R&D officials pointed out advantages to hiring term and temporary employees. For example, a particular research project may require specific expertise only for a finite amount of time, and hiring a term employee to fill this need allows the research station to harness that expertise without committing to maintaining it indefinitely—which is especially important if the expertise is unlikely to be needed for future projects. By not permanently filling scientist or technician positions, officials told us the agency retained the financial flexibility needed to conduct new research and maintain existing research platforms, including facilities, equipment, long-term plots, and other needed research elements.

Regarding external sources of funding, several FS R&D officials noted that increasing use of this funding, while a small portion of overall FS R&D spending, can have both positive and negative impacts. Several scientists and officials reported that external sources of support allowed them to expand the scope of their research by initiating work on additional research topics they would not otherwise have had the funds to pursue or to accelerate existing work—“to run where we would have walked instead,” in the words of one scientist. Some scientists also noted that, given the increasing demands on FS R&D appropriated funds, they have increasingly used external funds to help pay for research-related operating expenses.

In contrast, some scientists noted potential drawbacks in relying on external funding. Some FS R&D officials and scientists commented that external funding is generally available to support projects that span no more than a few years, and increasing reliance on external funding could therefore lead to a shift in FS R&D’s balance between basic and applied research if more of its scientists’ time were spent answering shorter-rather than longer-term research questions. Others, however, told us that pursuing external funding has helped ensure that FS R&D works on research questions relevant to stakeholders’ needs, because external funding tends to indicate the priorities of the broader research and user community. Furthermore, some told us that it can be time-consuming to identify and apply for such funding and that time spent on these tasks reduces the amount of time available for research.

FS R&D Has Recently Taken a Number of Steps to Improve Its Ability to Fulfill Its Mission, but Challenges Remain, Particularly in Science Delivery

FS R&D has recently taken steps to improve its ability to fulfill its mission in a number of areas, including science delivery, research relevance, organizational structure, research funding allocation, research agenda setting, and coordination with other federal research agencies. Despite the agency’s efforts, however, FS R&D officials and stakeholders identified challenges associated with these areas, particularly with regard to FS R&D’s ability to deliver the results of its research. In addition, agency officials identified several other challenges, which impede the agency’s ability to carry out its day-to-day work.

Modifications to Science Delivery

FS R&D has worked to create a more formal system for delivering the results of its research, known as science delivery, at multiple levels within the agency. FS R&D officials told us that at the national level, FS R&D in 2005 created a National Science Application Team and the position of National Science Application Coordinator, both focused on science delivery. According to officials, the team aims primarily at facilitating cross-station communication and identifying areas for strengthening science application activities throughout FS R&D. The team includes representatives from each station, as well as headquarters personnel. To date, according to an FS R&D official, the team has focused on identifying opportunities to collaborate across research stations so as to leverage each station's strengths. In addition to these actions, the Forest Service's 2007-2012 strategic plan recognized the importance of science delivery by including it as one of seven agency goals.

At the research station level, according to agency officials, science delivery positions have been or are being established at each station, although science delivery has evolved differently at each station and stations vary in the way they provide science delivery. For example, an FS R&D official told us the Pacific Northwest Research Station in the 1990s recognized the need for increased emphasis on science delivery to a broader audience, in part because of the Northwest Forest Plan, a highly controversial federal land management planning effort that required rigorous science to support decisions involving old-growth forests and threatened species. The station subsequently created a Focused Science Delivery program, whose mission is to enhance the usefulness of scientific information, including synthesizing information from a wide range of disciplines and delivering it to clients in clear and accessible formats. Likewise, the Rocky Mountain Research Station created the Science Application and Integration program, which is dedicated to making scientific information and research applicable to natural resource management and planning. The station is also working with partners to maximize efforts to address land managers' needs.²⁴ On the other hand, science delivery at the Forest Products Laboratory has been emphasized since its creation, according to laboratory officials, mainly because much

²⁴The station recently began to coordinate its efforts with those of the Southwest Ecological Restoration Institutes, which include Northern Arizona, Colorado State, and New Mexico Highlands universities. The institutes were established to help support land managers in implementing ecological restoration treatments, in part by transferring relevant and accurate scientific information to managers and other key stakeholders.

of the focus of the laboratory's research is on applied products, such as new wood materials for the housing sector.

Despite these efforts, officials and scientists throughout FS R&D, as well as numerous stakeholders, told us that FS R&D has not placed sufficient emphasis on science delivery. Some noted that, even with the agency's recent efforts, the agency does not have a consistent approach to science delivery, often leaving it up to individual scientists, who vary in the amount of time and effort they devote to it. Without effective delivery of FS R&D's research results, land managers, policymakers, and others may be unable to promptly and effectively use the knowledge, data, and tools FS R&D produces, and FS R&D cannot ensure that its research is being used to its greatest potential. In part, according to a senior FS R&D official we spoke with, the struggle to provide adequate science delivery stems from the contradictions inherent in FS R&D's status as a research organization within a land management agency. As a result, FS R&D must balance the limited time and resources available to its researchers between, on the one hand, basic research and the resulting publications in peer-reviewed journals and, on the other hand, delivering the results of that research and making sure it is useful and understandable to end users. Many stakeholders told us that although publishing research in peer-reviewed journals is important for the credibility of scientists and their research, delivery of results through other mechanisms—such as summary findings, workshops, or one-on-one interactions between scientists and users of FS R&D-developed work—can often be more useful to land managers and decision makers.

Nevertheless, many stakeholders and numerous FS R&D researchers and officials told us the agency values publications in peer-reviewed journals over other science-delivery mechanisms. In large part, according to several scientists and others we spoke with, this view prevails because the system for appraising individual researchers' performance continues to emphasize publication in peer-reviewed journals. To evaluate researchers, FS R&D uses the Office of Personnel Management's "research grade evaluation guide" to measure individual researchers' performance in what is often referred to as the paneling process. The guide was revised in 2006 to, among other things, place greater emphasis on communicating research results to users through mechanisms other than peer-reviewed journals (such as summary findings or workshops) as part of the measure of scientists' work. Officials told us that, consistent with these revisions, FS R&D made an effort to train panel reviewers to place greater emphasis on these other forms of science delivery as a component of their performance. Despite these changes, several FS R&D officials and

stakeholders told us that the emphasis placed on peer-reviewed journals, compared with other forms of science delivery, during the paneling process varies among panels and depends on the perspective of the panel chairperson; they also said that many panelists continue to emphasize peer-reviewed journals over other forms of science delivery.

Further complicating the science delivery issue is the potential overlap in science delivery roles between FS R&D and State and Private Forestry, another Forest Service program. State and Private Forestry is authorized by the Cooperative Forestry Assistance Act of 1978 to carry out a program of technology implementation to “ensure that new technology is introduced, new information is integrated into existing technology, and forest resources research findings are promptly made available to state forestry personnel, private forest landowners and managers, vendors, forest operators, wood processors, public agencies, and individuals.”²⁵ State and Private Forestry maintains staff across the country to assist in this mission, some of whom are closely associated with FS R&D’s work. Because both FS R&D and State and Private Forestry have missions to carry out science delivery, and because their activities can be closely intermingled, the programs’ science delivery responsibilities have not always been clearly delineated, according to officials, highlighting the need for both programs to work closely together to minimize duplication and stretch limited resources by taking advantage of available expertise across the programs. The need for greater clarity about FS R&D’s science delivery role in relation to State and Private Forestry is consistent with the results of the Forest Service’s own 2009 assessment of science delivery within the agency, which highlights deficiencies in this area, such as a lack of coordination among those conducting research and those delivering research information and tools, and provides suggestions for improvement, including greater coordination of efforts between FS R&D and State and Private Forestry.²⁶ FS R&D officials told us, however, that the agency has not taken steps to implement the report’s recommendations and has not established time frames for doing so, nor has the agency otherwise assessed the effectiveness of its efforts to improve science delivery, including the creation of the National Science

²⁵ 16 U.S.C. § 2107(c).

²⁶ *U.S. Forest Service, Final Report: Assessment of Technology Transfer within the USDA Forest Service* (Washington, D.C., 2009). As stated in the report, the purpose of this assessment was to improve the effectiveness and efficiency of science delivery to users of Forest Service information, science applications, technology, and delivery mechanisms.

Application Team and its changes to science delivery at the research stations.

It is important to note, however, that while many FS R&D officials and stakeholders suggested the need for greater attention to science delivery, many also emphasized the value of FS R&D's basic and long-term research and cautioned that too great a shift in resources from basic research to science delivery would also be inappropriate. Much of the applied research and science delivery relevant to current issues rests on the findings of basic, long-term research, so it is important to continue investing resources in such research, according to these stakeholders. For example, one State and Private Forestry official we interviewed told us that he found the wildland fire-related tools and assessments developed by FS R&D to be very useful, but he also emphasized the need for FS R&D to continue to invest resources in core fire science, which should not be driven by short-term needs, to maintain the agency's ability to develop such tools.

New Approaches for Ensuring Research Relevance

FS R&D has implemented new approaches to determine the relevance of its research work to customers and to assess its quality and performance, including customer surveys, external peer reviews of the seven strategic program areas, and an increased use of narrative descriptions to describe its accomplishments. In 2006, FS R&D began using a customer satisfaction survey to help identify areas where customers believed it excelled or, conversely, needed improvement.²⁷ Conducted periodically, the survey allows officials to assess overall customer satisfaction with FS R&D over time in comparison with other federal research agencies. According to survey results provided to us by FS R&D, the 2009 survey resulted in a 75-point score, which is in line with scores for other federal government providers of information, which typically score in the 70-point range, and was an improvement over FS R&D's 2006 score of 72. The survey also compares customer satisfaction across strategic program areas and research stations in a variety of categories, including accessibility of data, accuracy of products, and relevance and quality of work.²⁸ FS R&D officials told us they regard the information and recommendations

²⁷FS R&D uses the American Customer Satisfaction Index, developed by the National Quality Research Center at the University of Michigan, for its surveys.

²⁸Overall customer satisfaction varied by program area from 72 to 79 and by research station, from 69 to 83.

provided by the survey as useful for making better-informed determinations about the areas of work that require greatest improvement and are likely to have the greatest impact.

FS R&D also conducts external peer reviews that assess the relevance, quality, and performance of research conducted within each of its seven strategic program areas, an effort that began in 2006.²⁹ The relevance category, for example, includes assessing the extent to which each strategic program area has clear societal benefits, produces products that are being used and have potential impacts, seeks user input in setting the agenda, and is not inappropriately duplicative. The extent to which the reviews adequately measure performance in these areas, however, was questioned by several external reviewers as well as some agency officials. Although the strategic program areas are purposefully broad, this breadth of research coverage means that the work conducted under one area may also be relevant to another, complicating the review process. For example, it is difficult to fully evaluate how well Water, Air, and Soils is performing when areas of science relevant to that program area, such as the effects of smoke on air quality, may be evaluated under Wildland Fire. Because different external panels are assembled for each of the various peer reviews, it is hard to know where—or if—all areas of research were evaluated. Another concern on the part of some stakeholders was the degree to which end users provided feedback about the various strategic program areas and the implications of selecting certain end users for, or excluding them from, the peer-review process. Given that the strategic program areas and the review process are relatively new, FS R&D is currently evaluating the adequacy of such reviews in measuring performance, as well as ways in which the process might be improved.

Although FS R&D measures its performance in part with quantitative measures, such as number of publications and, in certain science areas, the numbers of tools developed, officials explained that it can be difficult to quantify many of its research accomplishments, such as FS R&D's research impact on preventing the outbreak of, for example, an invasive pest. To help overcome this difficulty, FS R&D communicates its accomplishments in reports through narrative descriptions of the scientific

²⁹These three categories are part of the research and development investment criteria for federal program evaluation, a set of guidelines for assessing the performance of federal research agencies. The criteria were initially articulated to the heads of federal departments and agencies by the Office of Management and Budget and the Office of Science and Technology Policy in 2002.

and societal benefits of its work.³⁰ In addition, researchers may work for years on a particular problem, which may not generate immediate, measurable outcomes but, rather, a valuable foundation for future accomplishments. For example, the information FS R&D currently contributes to climate research is based on data that have been collected over several decades.

Changes to FS R&D's Organizational Structure

Within the past few decades, the physical and organizational structures of FS R&D's research stations have also changed significantly. First, the makeup of the research stations changed, as some research stations merged and one split into two stations. Second, the research stations reorganized their work units into science themes or areas of research that are broader than in the past, to foster a more multidisciplinary and integrated approach to research.

Three of the present research stations resulted from merging previously existing stations, done in part to reduce overhead and administrative costs, as well as to improve customer service and make research results more accessible and useful. The Northern Research Station, for example, is the product of the agency's 2006 consolidation of the former Northeastern and North Central research stations; the Southern Research Station, formed in 1995, consists of the former Southeastern Forest Experiment Station and Southern Forest Experiment Station; and the Rocky Mountain Research Station, formed in 1997, consists of the former Intermountain Research Station and Rocky Mountain Forest and Range Experiment Station.³¹ According to FS R&D officials and documents, these mergers allowed related research to come under a single management team, while also allowing the stations to make better use of smaller administrative staffs; provided facilities for large-scale, multidisciplinary studies; and facilitated integrated, landscape-scale research programs. In

³⁰See, for example, U.S. Forest Service, *Forest Service Research and Development, Fiscal Year 2008*, FS-944 (Washington, D.C., 2010), and U.S. Forest Service, *USDA Forest Service Research and Development 2008-2009 Highlights*, FS-942 (Washington, D.C., 2009). The *Performance and Accountability Report* is a year-end progress report reviewing FS R&D's performance in relation to the Forest Service's strategic goals and objectives. The *2008-2009 Highlights Report* describes selected accomplishments by research area.

³¹We previously reported on the creation of the Rocky Mountain Research Station; see GAO, *Forest Service: Consolidation of the Rocky Mountain Forest and Range Experiment Station With the Intermountain Research Station*, GAO/01-53R (Washington, D.C.: Nov. 16, 2000).

contrast, the International Institute of Tropical Forestry, formerly a unit of the Southern Forest Experiment Station, was made an independent institute with an expanded mission in 1993.

In addition, beginning in the late 1990s, research stations reorganized their work into broad science themes or areas of research. Before that time, each research station was structured around discrete research work units, which were geographically based and covered specialized scientific issues. About 140 research work units existed across FS R&D, according to a FS R&D headquarters official, each of which included one to five scientists to carry out a narrow scope of work. As issues the scientists were studying grew in complexity, according to this official, more integration among disciplines was required to answer research questions. Officials at one research station, acknowledging their more complex research needs, observed that having narrowly focused research work units was no longer appropriate for the agency.

In response, FS R&D decided to consolidate the units into broader “programs,” which officials told us was to foster a multidisciplinary, integrated approach to research and reduce the time scientists spent on administrative tasks. While the research stations were not required to move from the research work unit model to the program model, the Deputy Chief of FS R&D encouraged them to do so, and all stations have now adopted the new approach.³² As a result, some research stations have undertaken major realignments of their units. For example, the Pacific Northwest Research Station has de-emphasized some traditional scientific areas while emphasizing new ones, moving from 26 research work units to six programs: Ecological Process and Function; Focused Science Delivery; Goods, Services, and Values; Land and Watershed Management; Resource Monitoring and Assessment; and Threat Characterization and Management.

The consolidation of research work units produced a number of benefits, according to FS R&D officials we spoke with. First, the consolidation

³²The Northern and Southern research stations and the Forest Products Laboratory have shifted their organizational structure to broader areas but continue to call these areas research work units, rather than programs. The Pacific Southwest Research Station plans to complete its shift from research work units to programs in the fall of 2010. The International Institute of Tropical Forestry has only one unit, Tropical American Forest Management, which has not been restructured; the institute continues to call this entity a research work unit.

allowed FS R&D to respond to increasingly complex research needs by adopting a more multidisciplinary and integrated approach. Second, according to officials, the consolidation of units shifted control back to research station management, allowing managers to be more strategic in setting research priorities because those priorities were determined centrally by the stations rather than individually by the units. For example, according to officials at the Rocky Mountain Research Station, in the past when employees resigned or retired, the research work units were permitted to directly refill the position. Now, the management team at the research station decides which vacancies to refill, including whether to shift vacant positions to other program areas that are higher priorities for the station. And third, the consolidation allowed FS R&D to use its resources more efficiently, according to agency officials, because the consolidation purged some traditional lines of research that FS R&D officials said were no longer productive or relevant. Consolidation also reduced overhead costs for FS R&D, as well as the time scientists spend on administration, according to officials, because it allowed FS R&D to consolidate scientists into fewer facilities. For example, as part of its consolidation, the Southern Research Station closed one of its laboratories and was also able to move two employees who were using Agricultural Research Service space into space owned by FS R&D. As a result, FS R&D was able to cease paying overhead costs for its use of the previous space. Despite these benefits, some officials described disadvantages to consolidating research units. For example, officials from the Southern Research Station said that consolidation decreased the station's on-the-ground presence in some places covered by the station, including Kentucky and Tennessee. Decreasing a station's presence may limit its partnerships with nonfederal entities, such as with industry, because local relationships can be more difficult to develop.

Although these recent changes may enhance FS R&D's work within stations, the decentralized nature of the agency's organizational structure emphasizes the need for collaboration across stations, and concerns have been raised about whether such collaboration could be improved. In particular, the external peer reviews of FS R&D's strategic program areas identified concerns about the extent to which research is being effectively coordinated across the research stations. For example, one peer review described a lack of coordination among research stations on wildland fire research, while another review found a lack of coordination in some areas of climate change research. On the other hand, while these concerns were echoed by a number of agency officials we talked with, other FS R&D officials, as well as agency stakeholders, noted a number of accomplishments that have come out of cross-station collaboration, such

as i-Tree and the Westwide Climate Change Resource Center Web site, developed by the Pacific Northwest, Pacific Southwest, and Rocky Mountain research stations.³³

Changes to Research Station Funding Allocation Processes

Along with consolidating their research programs, some research stations have also been revamping the process they use for allocating resources among programs and projects. At the Rocky Mountain Research Station, for example, officials told us that the new process begins when each program, laboratory, and experimental forest provides the station with its initial funding request. Subsequently, on the basis of these funding requests, as well as discussions about what programs or projects might be expanded or cut, the station's leadership team determines final allocations to each program, laboratory, and experimental forest. Later, a midyear review takes place to identify programs or projects that are unlikely to use all their funds; such funds are subsequently reallocated through a competitive process geared toward the station's priorities. Station officials told us that this new budgeting process better positions them to respond to emerging needs and priorities and helps clarify what the station's research dollars are funding. Similarly, the Pacific Southwest Research Station is implementing a new allocation process based on the one used by the Rocky Mountain station. In the past, according to station officials, each research work unit received a certain percentage of the station's total allocation, and this percentage did not change from year to year. By keeping the percentages fixed, these officials told us, the station did not have the needed flexibility to make funding changes in response to changing research priorities. The new process, according to a station official, allows managers to make more strategic and better-informed decisions.

Other stations' processes likewise are aimed at ensuring that research dollars are directed to the highest-priority research areas, rather than simply continuing previous funding patterns. At the Pacific Northwest Research Station, officials told us they use four factors to guide resource allocations so they can balance the need for basic science with emerging research areas. The first factor is the period of science delivery: the station allocates about 40 percent of its resources to research expected to deliver knowledge and tools within 1 to 3 years. Second, officials consider the

³³FS R&D officials told us the resource center will be expanding to include information provided by the Northern and Southern research stations as well.

relevance of each research program or project and its broader applicability; third, the regional significance of the research; and fourth, the extent to which a program or project is in an emerging growth area. At the Forest Products Laboratory, officials told us that funding decisions are based largely on the research needs identified by the station's scientists and assistant directors, who meet to discuss research needs and determine where to make trade-offs between research areas.

Some officials also noted that FS R&D leverages its staff resources by considering resource needs and vacancies across stations and that applying resources across geographic boundaries—or even permanently transferring researchers to locations where they can be better used—allows the agency to apply its expertise quickly and efficiently. By way of example, an official at the Pacific Southwest Research Station told us that a bark beetle researcher at the station spends as much time in other states experiencing bark beetle outbreaks as he does in California, where the station is located, and that, even though these other states are covered by other research stations, it is more efficient to meet this research need through existing expertise than to hire scientists in these other locations. Because FS R&D leverages its resources across geographic boundaries, according to officials, the location of staffing resources around the country does not limit the agency's ability to respond to research needs even in areas where FS R&D staff are not permanently located.

Increased Stakeholder Involvement in Setting Research Agendas

FS R&D has been renewing its efforts to seek and obtain input on research agendas from stakeholders—including federal and state land managers, universities, and industry—by, for example, conducting outreach to identify stakeholders' research needs and soliciting their input before undertaking particular research efforts. Within the last several years, FS R&D has participated in several nationwide, large-scale efforts to identify research priorities related to forestry. For example, beginning in 2005, FS R&D participated in a series of workshops as part of the Forest Service Outlook Project, aimed at developing a long-term research agenda in collaboration with the broad forestry community, including federal, state, and local government agencies; the business community; nongovernmental organizations; and academic institutions. Also in 2005, officials from FS R&D participated in creating the *Forest Products Industry Technology Roadmap*, a report aimed at helping reinvent and reinvigorate the U.S.-based forest products industry, including the role of

FS R&D research in doing so.³⁴ Other, program-specific efforts exist as well; for example, officials pointed out that the FIA program holds annual meetings with regional and national user groups on the program's implementation.

Many stakeholders we interviewed told us that they meet regularly with research station directors to discuss research priorities and research progress and that, particularly over the last 5 to 6 years, their relationships with FS R&D officials and researchers have continued to improve. For example, one stakeholder told us that the Rocky Mountain Research Station Director holds quarterly meetings with the Regional Foresters of the four National Forest System regions covered by the station to learn more about their research needs. The same Station Director recently held a needs assessment meeting to solicit input from foresters at national forests, as well as state foresters and research station scientists, about what they perceive to be gaps in research. In addition, several stakeholders told us that FS R&D researchers are generally willing to take stakeholder interests into account when implementing research activities, and some pointed out instances in which researchers adapted their research to address stakeholder concerns. For example, one stakeholder noted that FS R&D researchers at the Silas Little Experimental Forest in New Jersey added a component to their work in response to state forester concerns about loss of canopy cover and fire impact resulting from gypsy moths, an issue of particular concern for northeastern foresters. In another example, a western stakeholder we interviewed told us that land managers from the National Forest System met with an FS R&D researcher studying the locations of, and reasons for the decline in, bull trout, a federally listed threatened species. The land managers wanted information about specific aspects of bull trout habitat that the researcher had not initially included in his research plan, but, as a result of the meeting, the researcher incorporated these additional aspects into his study, thereby increasing its relevance. Several stakeholders also mentioned that regional forums, such as the Western Forestry Leadership Council—a partnership between state and federal government forestry leaders in which FS R&D officials and scientists interact directly with state foresters in the West—were effective for discussing both research priorities and work under way.

³⁴Agenda 2020 Technology Alliance and Energetics Incorporated, *Forest Products Industry Technology Roadmap*, a report sponsored by the American Forest and Paper Association and the Department of Energy, July 26, 2006.

Despite strong relationships and multiple opportunities to provide input, however, several stakeholders we interviewed believed that more could be done to increase end-user input in setting research agendas. Some stakeholders told us they did not always have sufficient opportunity to voice their research interests and suggested that a more systematic approach to communication with FS R&D was needed to ensure their input was considered. According to one stakeholder, private landowners may have fewer opportunities to provide input on research agendas because conferences where research agendas are discussed may be too expensive for them to attend or because they are not made aware of such opportunities to participate. Similarly, despite FS R&D efforts to solicit university input, the university representatives we interviewed told us that FS R&D should make a more concerted effort to involve academia in FS R&D's early planning efforts.

Although considering the priority needs of stakeholders is important, FS R&D officials and researchers must also maintain discretion to prioritize research they consider important even in the face of stakeholder disagreement. Officials at the Forest Products Laboratory, for example, told us that stakeholder input into the laboratory's work is reviewed annually through a peer-review process conducted by multiple end users—including other research stations, universities, and industry—to ensure the laboratory is working on relevant science and evaluate the work it considers for the future. Officials told us that some panelists criticized the laboratory over the past 20 years for conducting research on nontoxic wood preservatives to serve as alternatives to the widespread use of traditional wood preservatives, stating that such research was unnecessary. Because of concerns about traditional wood preservatives' potential harm to human health and the environment, however, scientists and managers at the laboratory felt that research into alternatives was important. As a result, they continued to pursue this research despite end-user suggestions, which officials told us proved to be important because the use of the older preservatives is now restricted.³⁵

³⁵Traditional wood preservatives, used in pressure-treated wood since the 1940s, helped prevent wood rot due to insects and microbes. Such wood preservatives, however, contained the toxic metals arsenic, chromium, and copper, and pressure-treated wood containing the preservatives is no longer being produced for use in most residential settings.

Emphasis on Coordination with Other Agencies

FS R&D has emphasized coordination with other federal research agencies at various levels to leverage expertise and resource capacity and set complementary research agendas. For example, current federal interest in using biomass as a reliable source of energy requires integrating various components of research and information unique to several different agencies, such as methods for acquiring a sufficient supply of biomass feedstock and converting this feedstock into energy. Officials we interviewed from other agencies provided a large range of research issues in which FS R&D is currently coordinating with multiple federal agencies or research entities, including bioenergy, climate change, water quality, restoration, and management across landscapes, and many stated that coordination is increasing. For example, one official from USGS noted that as recently as 5 years ago, he was aware of few coordinated efforts across the Forest Service and USGS in the area of water research, but the situation has since changed.

At the national level, FS R&D and other agency officials described the coordination undertaken with other federal agencies in a number of ways, including interagency working groups, conferences, and regular meetings. Within the Department of Agriculture, FS R&D broadly coordinates its research with other component research agencies, including the Agricultural Research Service and National Institute of Food and Agriculture, by holding regular meetings to discuss research policy, mutual research interests, and potential areas for coordination. FS R&D also coordinates with agencies outside of the Department of Agriculture, including USGS and the Bureau of Land Management in the Department of the Interior, the Environmental Protection Agency, the Department of Energy, and the National Science Foundation. Current efforts include collaboration with Energy on biomass, USGS on carbon sequestration,³⁶ and multiple agencies on climate change. Specifically:

- *Biomass.* The departments of Agriculture and Energy co-chair a biomass research and development board charged with coordinating programs across federal agencies to promote the use of biofuels and biobased products. The Department of Agriculture has the lead on biomass feedstock research while Energy has the lead on techniques to convert feedstock into fuel, according to FS R&D and other agency officials.

³⁶Terrestrial carbon sequestration is defined as either the net removal of carbon dioxide from the atmosphere or the prevention of carbon dioxide net emissions from terrestrial ecosystems, such as forests and agricultural lands, into the atmosphere. Carbon sequestration also occurs in the oceans.

Within the Department of Agriculture, FS R&D and the Agricultural Research Service are developing a network of Biomass Research Centers, through which they will coordinate their agencies' efforts to provide biomass for the biofuels industry. The network will comprise existing Agricultural Research Service and Forest Service facilities and scientists, whose combined efforts, along with partnerships with universities and private companies, are expected to help accelerate the commercial production of biofuels, biopower, and other biobased products.

- *Carbon sequestration.* The Energy Independence and Security Act of 2007 directs federal agencies to coordinate on a number of efforts, including an assessment of national capacity for geological sequestration of carbon. Through the act, the Secretary of the Interior was directed to complete this assessment with other federal agencies. The assessment has geological and biological components, according to an official, with FIA data from FS R&D expected to play a substantial role in the assessment.
- *Climate change.* FS R&D collaborates with multiple federal agencies on issues related to climate change. For example, FS R&D is involved in the U.S. Global Change Research Program, which coordinates and integrates federal research on changes in the global environment and their implications for society. Thirteen federal departments and agencies participate in the program, including the departments of Commerce, Defense, and Energy, and the National Aeronautics and Space Administration. FS R&D also works directly with USGS on a number of climate change initiatives. For example, USGS is developing eight climate change response centers around the country; the Forest Service is on the steering committee for the centers, and FS R&D and USGS will conduct joint research out of these centers.

FS R&D is also involved in a number of interagency efforts at regional and local levels. For example, FS R&D is working with multiple federal agencies in a variety of climate change partnership efforts. One such partnership is the Consortium for Integrated Climate Research in Western Mountains, a network of scientists, resource managers, and policymakers from the Forest Service, the National Oceanic and Atmospheric Administration, USGS, and universities that promotes climate monitoring, research, communication, and decision support in the West. FS R&D is also involved in the Great Basin Resource and Management Partnership, through which FS R&D and a number of other federal agencies, including the Bureau of Land Management, the Fish and Wildlife Service, and USGS, as well as nonfederal entities such as universities and nongovernmental organizations, are working to better link research to management in the

Great Basin, considered by some scientists to be one of the most endangered ecoregions in the United States.³⁷ At the local level, officials told us that in Alaska, scientists from USGS and FS R&D worked together on a joint project to forecast shifts in polar bear populations because of climate change, work influential in the listing of the polar bear as a threatened species under the Endangered Species Act.³⁸ In the Southern Research Station, the Coweeta Hydrologic Laboratory was designated as a National Science Foundation Long-Term Ecological Research Site in 1980. At this site, FS R&D, the National Science Foundation, and the University of Georgia share facilities, staff, equipment, and funding to coordinate research on rainfall, evaporation, and stream flow.

In general, according to many officials from FS R&D and other agencies, FS R&D's scope of work complements, rather than duplicates, other agencies' work. For example, while FS R&D and the Agricultural Research Service both do research on plants, FS R&D focuses mainly on trees while the Agricultural Research Service focuses on herbaceous (nonwoody) crops, resulting in minimal overlap, according to officials. Similarly, FS R&D and USGS both conduct water research, but the bulk of FS R&D's research on water focuses on forest systems and wildland fire, according to officials, while USGS's water program has more breadth and provides more of a "census report" of water, including information on water supply and quality. The generally complementary, rather than overlapping, nature of research prevails in part because FS R&D's structure and mission differ from those of other federal agencies conducting research, according to FS R&D and other agency officials we spoke to. Several officials at various agencies told us that FS R&D's unique position as part of a land management agency gives its work a specific focus that tends not to overlap with the work of other federal research agencies, which are primarily research agencies with no land management responsibilities.

Other Challenges in Carrying Out Day-to-Day Activities

FS R&D officials also reported several challenges that impede their ability to conduct their day-to-day research, including computing and information technology, human capital, and other administrative issues.

³⁷The Great Basin desert ecoregion covers most of Nevada and parts of Oregon, Idaho, Utah, and California.

³⁸The Endangered Species Act of 1973 protects plant and animal species that are either facing extinction (endangered species) or likely to face extinction (threatened species) and protects the ecosystems on which they depend.

Computer and Information Technology Issues

Many FS R&D officials and scientists told us that issues related to computer and information technology impede their ability to carry out their work. FS R&D officials explained that researchers generally require greater computing capacity than most other Forest Service employees; for example, many researchers collect substantial amounts of data and develop and use complex software applications. To understand the specific information technology needs of FS R&D, an official from the Chief Information Office for the Forest Service conducted a review of technical challenges for FS R&D, which began in August 2007 and produced an internal report in January 2009. The report identified a number of “priority issues,” along with recommendations, some of which were also frequently mentioned during our interviews with FS R&D officials. These include insufficient customer service and support, with multiple days needed to resolve routine computer issues; the long technical approval process for researchers to use technology outside current Forest Service information architecture; and insufficient computing capacity, which can require researchers to rely on partners such as universities to store and run FS R&D data and programs.

Since the report was issued, the Chief Information Office has taken some steps to address cited issues, and some FS R&D officials told us that information technology support is improving. For example, officials told us that the information office created a customer service representative specifically for FS R&D and is revamping its system for entering requests for technical approval. In addition, officials told us the information office has implemented a pilot project aimed at improving high-end computing capacity.

Human Capital

Several FS R&D officials told us that the Forest Service’s hiring process sometimes impedes research. Human resource management was one of the administrative functions the Forest Service centralized, a move that may have contributed to dissatisfaction with the hiring process because research stations no longer have human resource support on site as they did in the past. Many FS R&D officials complained about the length of that process, pointing out that, because the process can take so long, temporary employees may begin work later than anticipated, shortening the time they have to collect data for research projects. In some cases, data can be collected only in certain months of the year; for example, the field season in high alpine areas may be limited to a short period in the summer, exacerbating the effects of hiring delays. In addition, according to officials, the length of the process can sometimes cause research stations to lose good candidates, if those candidates choose another employer who can hire them more quickly.

Administrative and Legal Challenges

Another issue that FS R&D faces when hiring new employees is that position descriptions are sometimes changed by the Forest Service's Human Resource Management office because employees there may not understand the unique needs of research stations, according to FS R&D officials. In scientific research, specific qualifications need to be considered in filling research positions. For example, some officials told us that a researcher may need to hire a technician who can mimic certain bird calls and will include that requirement in the position description. Human resource management officials, however, may take the specification out because they think it is superfluous and too specific. Likewise, two research positions with the same title might require different skills or expertise, but, according to officials we interviewed, human resource management officials may not understand the distinctions.

Administrative and legal challenges were also cited as hampering FS R&D research. For example, the Paperwork Reduction Act contains review requirements associated with developing surveys, which FS R&D researchers told us are an obstacle to using surveys to obtain information from nonfederal stakeholders.³⁹ The act prohibits federal agencies from conducting or sponsoring information collection unless they have prior approval from the Office of Management and Budget. The act requires that information collection be approved by the office when facts or opinions are solicited from 10 or more people, including through surveys, questionnaires, and focus groups. FS R&D officials told us that this process is long and arduous—noting that it can take 1 to 2 years to get surveys approved—which can prevent researchers from obtaining timely information and sometimes dissuade them from administering surveys to nonfederal stakeholders so as to avoid the process entirely.⁴⁰ Consequently, these researchers rely more heavily on federal stakeholders to obtain input, use secondary data that already exist, or depend on external partners to collect information for them. The requirements associated with the act affect social science in particular, according to

³⁹ 44 U.S.C. § 3507. The purpose of the act is to (1) minimize the federal paperwork burden for individuals, small businesses, state and local governments, and other persons; (2) minimize the cost to the federal government of collecting, maintaining, using, and disseminating information; and (3) maximize the usefulness of information collected by the federal government.

⁴⁰ We have previously reported on the limitations associated with this requirement. See, for example, GAO, *Paperwork Reduction Act: New Approaches Can Strengthen Information Collection and Reduce Burden*, [GAO-06-477T](#) (Washington, D.C.: Mar. 8, 2006).

officials, because social scientists tend to rely more heavily on data developed through surveys and questionnaires than do scientists from other disciplines.

An additional legal and administrative challenge noted by FS R&D officials is that the agency is restricted from directly applying for certain funding sources. Under the National Science Foundation's grant policy, this agency does not normally support research or education activities by scientists, engineers, or educators employed by other federal agencies.⁴¹ Accordingly, FS R&D does not apply for National Science Foundation grants (and some other grants) as the principal investigator and funding recipient. Rather, FS R&D must work with a nonfederal entity (e.g., a university) that applies for this funding, meaning that the nonfederal entity becomes the principal investigator and funding recipient. Some officials believed these grants should be open to the entire science community and noted that funding FS R&D directly may be more efficient because FS R&D researchers may have expertise in certain areas, as well as the ability to maintain long-term research.

Conclusions

The breadth of the research carried out by FS R&D, and the value placed on that work by the many who use it, reflects the agency's efforts to produce high-quality scientific information and tools to help manage our nation's forests and rangelands. This research is likely to be even more important in the future, as a complex web of increasing stresses on ecosystems crisscrossing multiple ownership boundaries tests the ability of land managers, policymakers, and others to respond. FS R&D has positioned itself to respond to these stresses, as evidenced by its research into climate change, wildland fire, invasive species, and other topics of immediate interest, by the steps it has taken to help ensure its research is relevant, and by its emphasis on cross-cutting research that spans multiple issues, ecological settings, research partners, and customers.

But research is only part of FS R&D's mission, and the ultimate success of the research program depends on effective ways to deliver the resulting

⁴¹Transferring funds between appropriations accounts (such as those funding National Science Foundation and Forest Service activities, respectively) is prohibited absent specific statutory authority. 31 U.S.C. § 1532. The law is one aspect of congressional "power of the purse"—the power of Congress to appropriate funds and to prescribe the conditions governing the use of those funds. See GAO, *Principles of Federal Appropriations Law*, [GAO-04-261SP](#) (Washington, D.C.: January 2004), 1-3.

knowledge and technology. Recognition is growing on the part of FS R&D management that more emphasis needs to be placed on this process, as shown by the steps taken to (1) create the National Science Application Team, (2) increase emphasis on science delivery at the research station level, and (3) commission a science delivery review in 2009. Nevertheless, the agency has not fully assessed the effectiveness of its efforts to improve science delivery, which remains a largely ad hoc process that is often subject to the availability and interests of individual scientists. Part of this unevenness arises because individual performance assessments emphasize research and science delivery through peer-reviewed publications more than other methods of science delivery that often convey research results and the use of those results to broader audiences. Without assessing the adequacy of steps taken to improve the agency's science delivery efforts—and without ensuring that individual performance assessments appropriately value and reward these other methods of science delivery—the benefits of FS R&D's extensive research efforts may not be fully realized.

Recommendations for Executive Action

To maintain and strengthen the science delivery role of FS R&D and help the agency capitalize on the steps it has taken in this area, we recommend that the Secretary of Agriculture direct the Chief of the Forest Service to take the following two actions:

- Assess the effectiveness of recent steps FS R&D has taken to improve science delivery from FS R&D to land managers and other stakeholders, including the extent to which these steps have helped ensure that FS R&D's work is disseminated beyond the agency and communicated to its broad range of potential stakeholders. In assessing the effectiveness of these steps, the Chief should consider the recommendations of the Forest Service's 2009 assessment of science delivery.
- Take steps to ensure that individual performance assessments better balance the various types of science delivery activities.

Agency Comments and Our Evaluation

We provided a draft of this report to the Forest Service for comment. The Forest Service agreed with our findings and recommendations, and noted several actions that it intends to take to improve science delivery. In particular, the agency will begin to assess the effectiveness of its recent steps to improve science delivery and commit additional resources to strengthen science delivery; it will amend its guidance for, and update its training on, holding evaluation panels for research scientists so that

science delivery receives more emphasis; and it will continue to recognize and provide incentives for science delivery activities. The agency noted, however, that its flexibility to modify its approach to these evaluation panels is limited because it must follow Office of Personnel Management regulations and policies. The Forest Service's written comments are reproduced in appendix IV.

Unless you publicly announce the contents of this report earlier, we plan no further distribution until 30 days from the report date. At that time, we will send copies of this report to the appropriate congressional committees, the Secretary of Agriculture, the Chief of the Forest Service, and other interested parties. In addition, this report is available at no charge on the GAO Web site at <http://www.gao.gov>.

If you or your staff have questions about this report, please contact me at (202) 512-3841 or mittala@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. Key contributors to this report are listed in appendix V.

Sincerely yours,



Anu K. Mittal
Director, Natural Resources
and Environment

Appendix I: Objectives, Scope, and Methodology

Our objectives were to identify (1) the scope of research and development carried out by Forest Service Research and Development (FS R&D) and some of its resulting accomplishments; (2) trends in resources used in performing FS R&D work and the effects of those trends on its research efforts and priorities; and (3) recent steps FS R&D has taken to improve its ability to fulfill its mission, and challenges it faces in doing so.

To obtain information on the scope of FS R&D's work and its accomplishments, we reviewed relevant laws, regulations, guidance, strategic plans, performance reviews, and historical documents and interviewed FS R&D officials at each of the seven research stations and the Washington Office. We visited five research stations in person (the Northern, Pacific Northwest, Pacific Southwest, Rocky Mountain, and Southern research stations) and interviewed officials from the other two research stations by telephone. Within each of the research stations, we interviewed a variety of officials, including the station directors, budget officers, human resource management officials, scientists, and others. At the Washington Office, we interviewed the Forest Service's Deputy Chief of Research and Development, the directors of FS R&D's four major science areas, and the acting and former National Science Application Team coordinators. To obtain stakeholders' views about FS R&D's activities and accomplishments, we conducted semistructured interviews of National Forest System and State and Private Forestry officials from the Washington Office and all nine Forest Service regions, including each Regional Forester or designee, as well as nonagency stakeholders representing a variety of interests such as industry, academia, and others. These stakeholders included the American Forest and Paper Association, the National Association of University Forest Resource Programs, the National Association of State Foresters, the National Woodland Owners Association, and others.

To identify trends in resources used by FS R&D and the effects of those trends on research efforts and priorities, we obtained and analyzed spending and personnel data and interviewed scientists and officials at its research stations and the Washington Office. To identify spending trends for FS R&D, we obtained outlay data for fiscal years 2000 through 2009 from the Department of Agriculture's Foundation Financial Information System, including data on spending using both Forest Service appropriations and external funding. We analyzed these outlays by spending category (i.e., personnel, grants and agreements, training) for FS R&D as a whole and for each of the research stations and the Washington Office. To identify the sources of external support, as well as total external funding and the number of projects supported, we obtained and analyzed

data from I-Web, a Forest Service database used to track agency agreements. Because I-Web was established in 2005, we were able to report detailed information about external support only for fiscal years 2005 through 2009. We analyzed outlay and external support data in both nominal (actual) and constant (adjusted for inflation) terms. Adjusting nominal dollars to constant dollars allows the comparison of purchasing power across fiscal years. To adjust for inflation, we used the gross domestic product price index with 2009 as the base year. To identify effects of resource trends on FS R&D's work, we interviewed scientists and officials at the research stations about these trends and how they have affected research efforts and priorities. To corroborate officials' statements about their hiring practices and staffing levels, we analyzed the Department of Agriculture's National Finance Center data on permanent, temporary, and term employees provided to us by the FS R&D Washington Office for fiscal years 2006 through 2009; data from previous fiscal years were not available for analysis. We assessed the reliability of the spending, funding, and personnel data we used in our report by reviewing the methods of data collection and entry for these databases and determined that the data were sufficiently reliable to use in this report.

Finally, to identify steps FS R&D has taken to improve its ability to fulfill its mission and challenges it has faced in doing so, we reviewed relevant laws, regulations, guidance, strategic plans, performance measures, and recent research capacity and program assessments. We also relied on our interviews with FS R&D officials at the research stations and the Washington Office, and interviewed officials from the Forest Service's Chief Information Office to learn about FS R&D's computer and information technology challenges and what steps the office is taking to address them. In addition, during our interviews of National Forest System and State and Private Forestry officials and representatives from industry, state government, and nonfederal groups, we asked their views of the relevance of FS R&D work and what, in their opinion, could be done to improve it. To determine the extent to which FS R&D coordinates its work with other federal agencies to avoid unnecessary duplication of research, we also interviewed officials from other agencies that conduct research similar to that of FS R&D. To identify other federal agencies, we relied on the results of our interviews with FS R&D officials and stakeholders and reviewed National Science Foundation data to identify any additional agencies that conduct research and development similar to FS R&D that were not identified by the officials we interviewed. From our comprehensive list of federal agencies, we selected a nongeneralizable sample of five agencies: the Agricultural Research Service within the Department of Agriculture; the Office of Energy Efficiency and Renewable

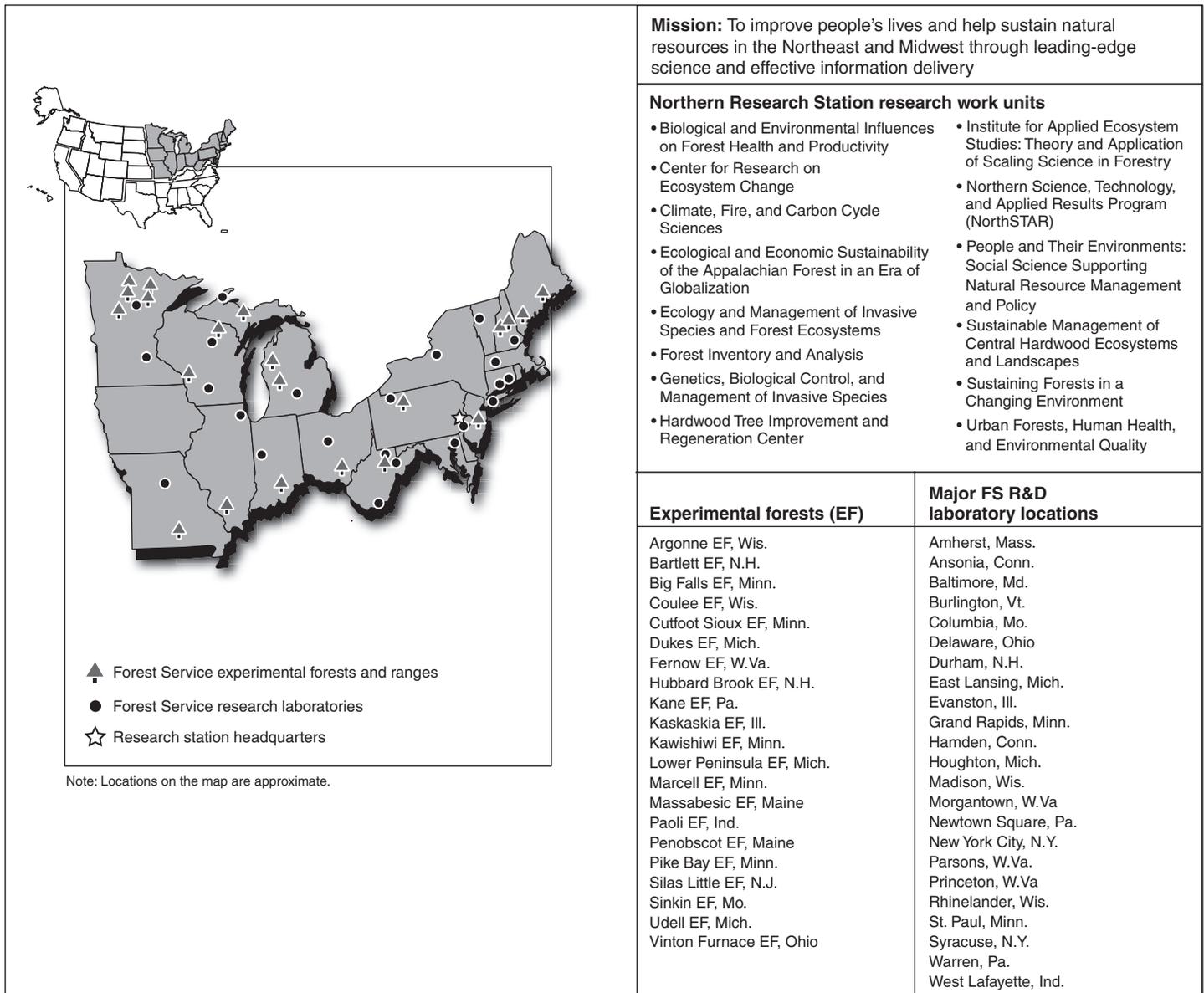
Energy within the Department of Energy; the Environmental Protection Agency; the National Oceanic and Atmospheric Administration within the Department of Commerce; and the U.S. Geological Survey within the Department of the Interior. We also reviewed results from the American Customer Satisfaction Index, the survey FS R&D uses to assess customer satisfaction. Although the response rate for this survey was limited, it is comparable to the rates obtained in surveys used to assess customer satisfaction with other agencies.

We conducted this performance audit from October 2009 through October 2010, in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: FS R&D Research Stations

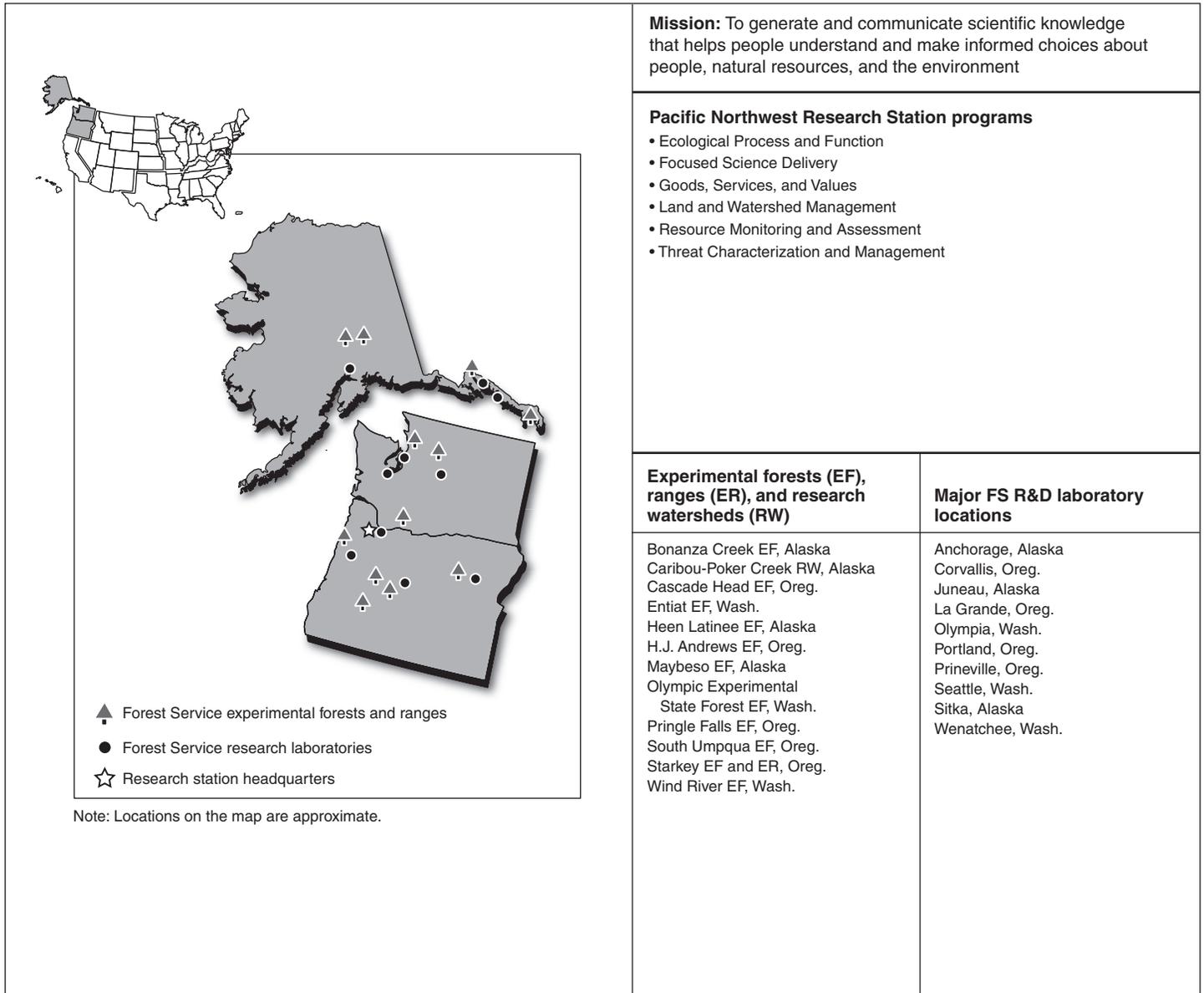
The following seven figures depict and identify the mission, geographic coverage, research facility locations, and research subject areas of the seven FS R&D research stations.

Figure 6: Northern Research Station



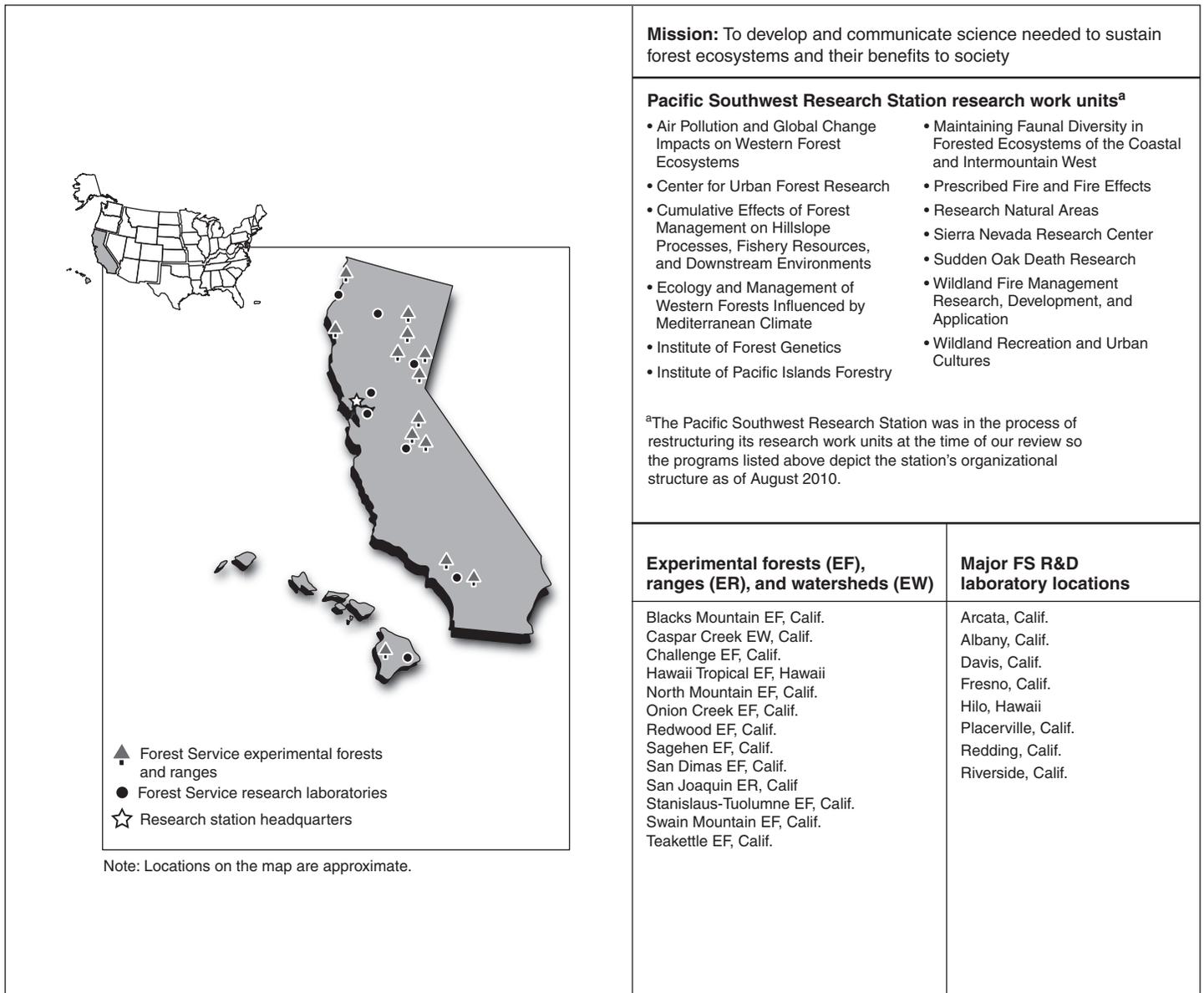
Source: GAO and Forest Service.

Figure 7: Pacific Northwest Research Station



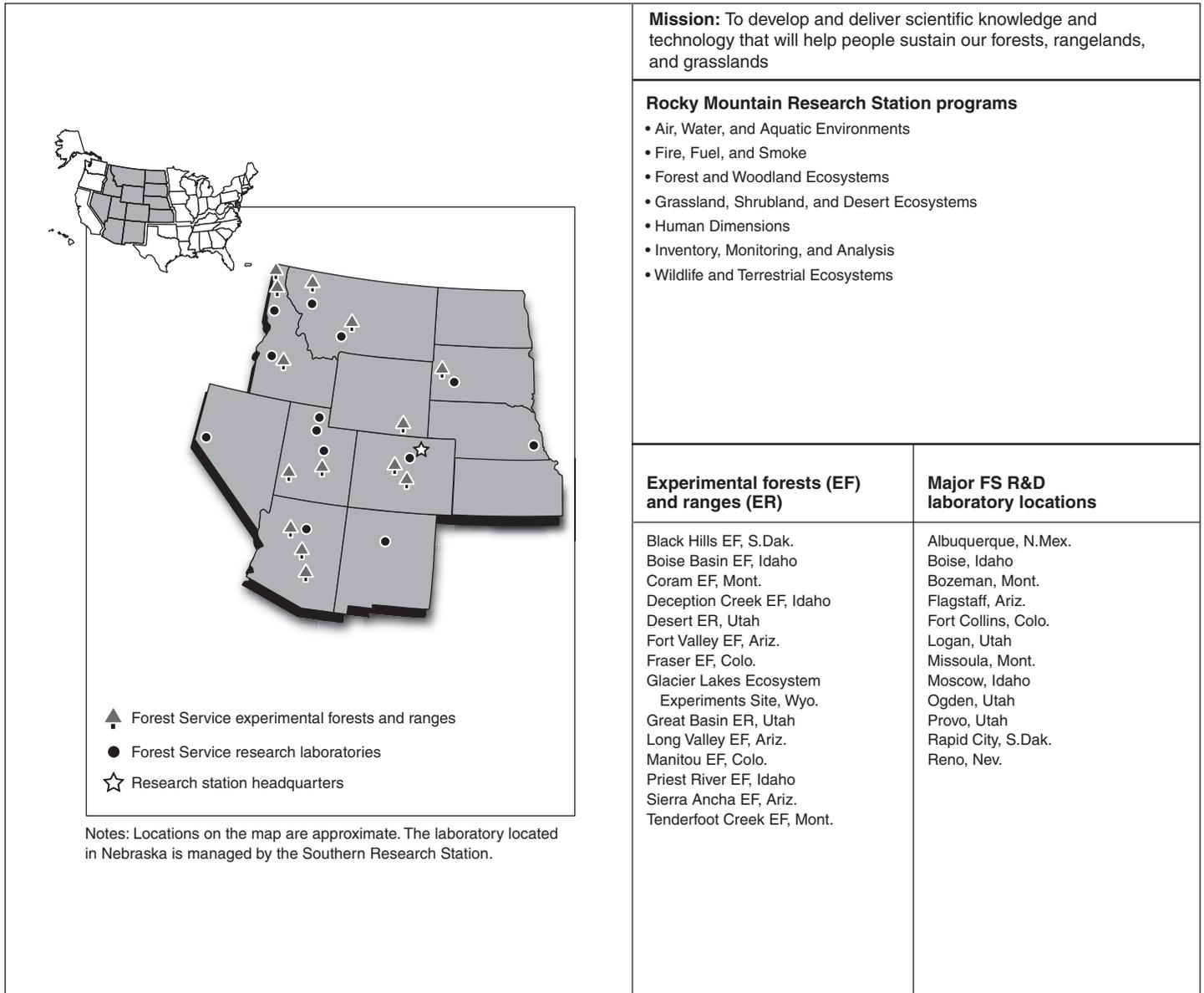
Source: GAO and Forest Service.

Figure 8: Pacific Southwest Research Station



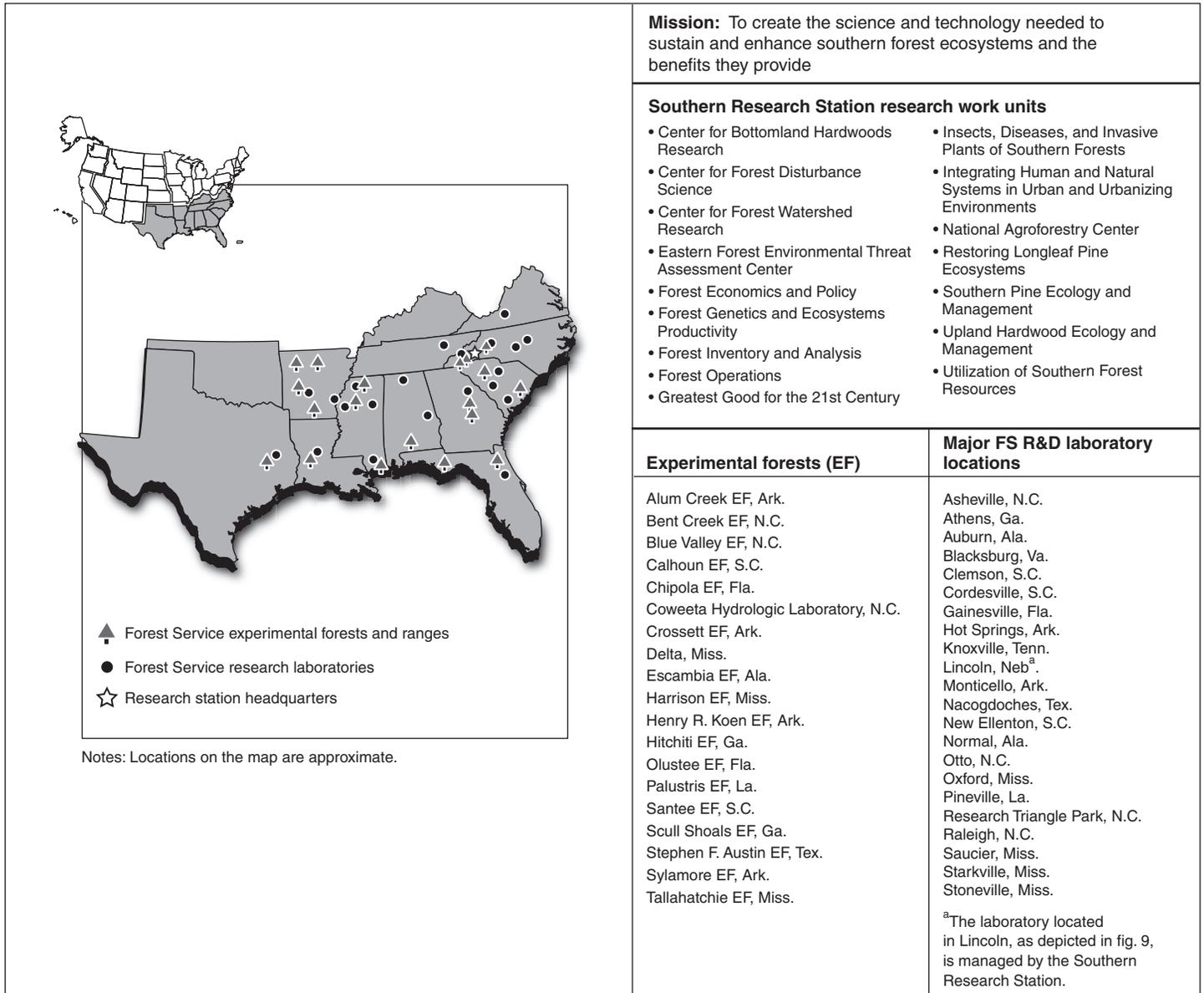
Source: GAO and Forest Service.

Figure 9: Rocky Mountain Research Station



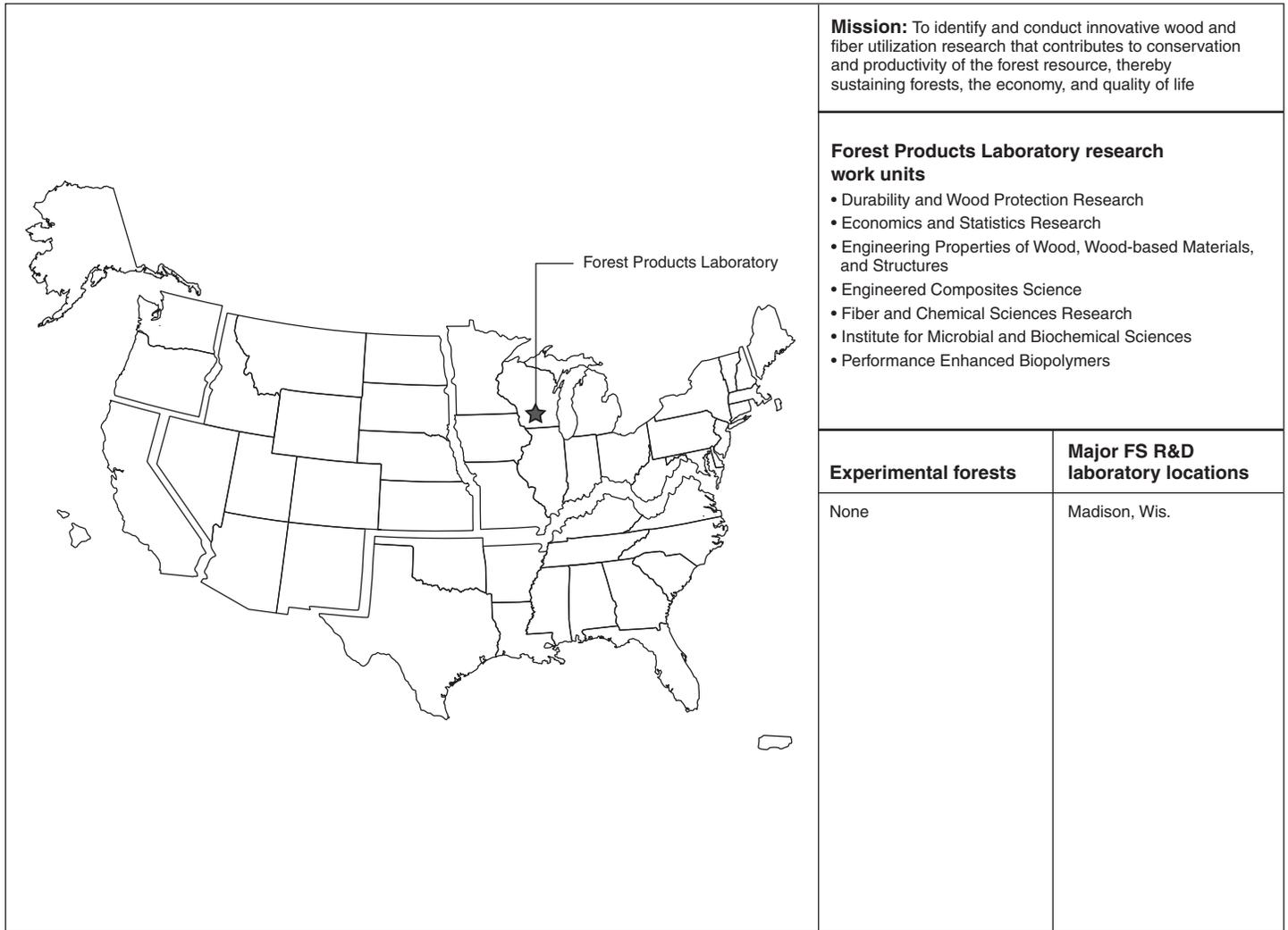
Source: GAO and Forest Service.

Figure 10: Southern Research Station



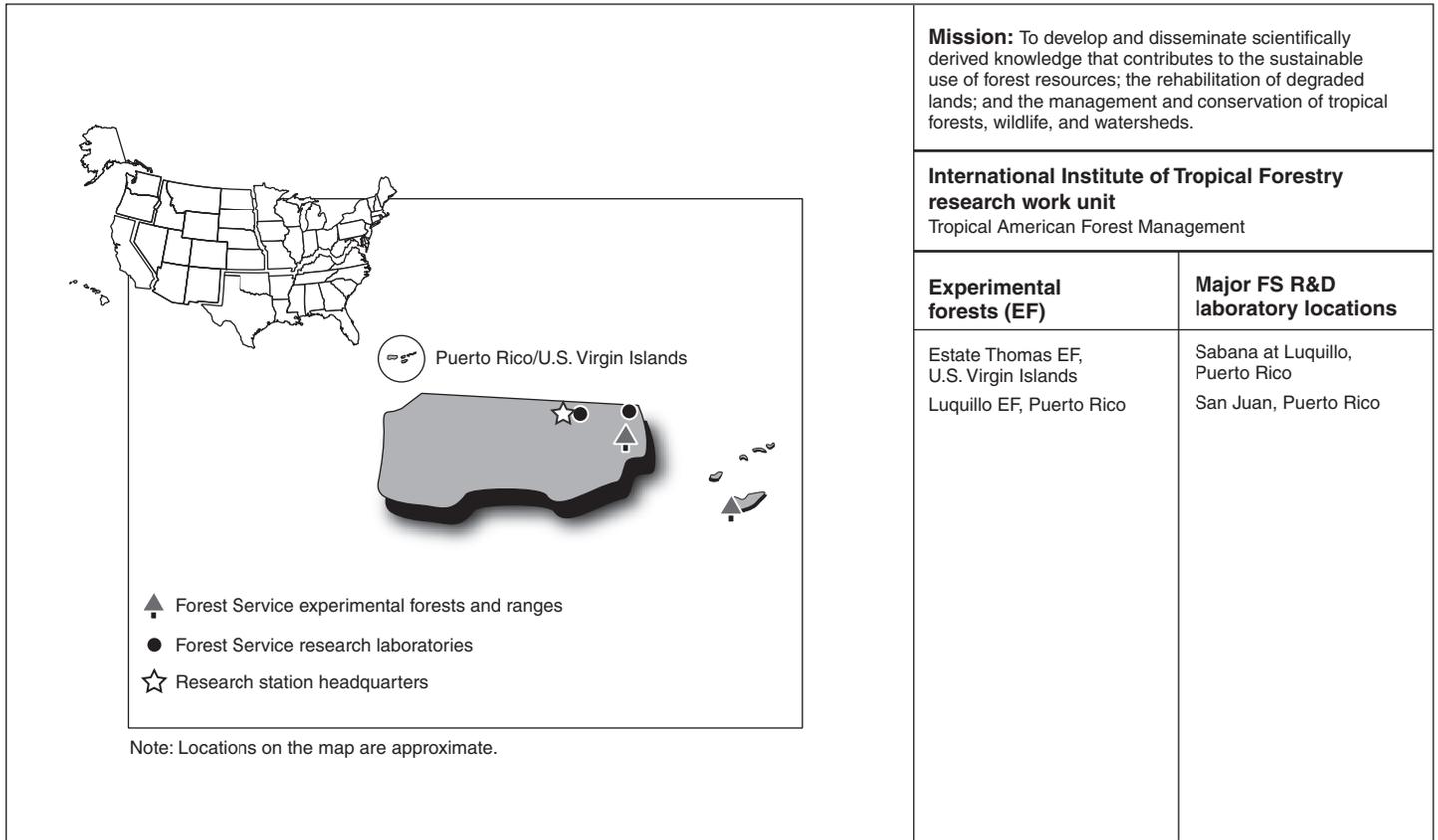
Source: GAO and Forest Service.

Figure 11: Forest Products Laboratory



Source: GAO and Forest Service.

Figure 12: The International Institute of Tropical Forestry



Source: GAO and Forest Service.

Appendix III: Forest Service Research and Development Spending and Personnel Data, by Research Station

This appendix provides data on FS R&D spending and personnel trends across the research stations. Table 2 shows yearly spending by the research stations.

Table 2: Spending Using Forest Service Appropriations by Research Station, Fiscal Years 2000 through 2009

Dollars in millions

Research station	Fiscal years									
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Forest Products Laboratory										
Nominal	\$22.9	\$22.9	\$22.5	\$27.8	\$30.2	\$28.8	\$23.1	\$41.2	\$37.8	\$39.5
Inflation-adjusted	28.4	27.8	26.9	32.5	34.5	31.8	24.6	42.8	38.3	39.5
International Institute of Tropical Forestry										
Nominal	5.7	7.3	7.0	8.5	8.4	6.6	8.0	7.1	6.4	6.0
Inflation-adjusted	7.1	8.9	8.4	10	9.6	7.3	8.5	7.4	6.5	6.0
Northern										
Nominal	48.4	50.3	55.7	68.8	75.1	65.0	65.3	62.9	66.6	69.5
Inflation-adjusted	60.1	61.1	66.6	80.5	85.7	71.9	69.7	65.3	67.6	69.5
Pacific Northwest										
Nominal	46.1	44.1	48.3	53.7	53.9	46.6	52.6	48.5	47.0	49.4
Inflation-adjusted	57.3	53.6	57.7	62.8	61.5	51.5	56.2	50.3	47.7	49.4
Pacific Southwest										
Nominal	25.3	24.7	30.7	38.2	38.9	36.4	32.5	27.7	30.6	34.6
Inflation-adjusted	31.5	30.0	36.7	44.7	44.4	40.2	34.7	28.8	31.1	34.6
Rocky Mountain										
Nominal	42.0	50.4	58.6	63.9	72.4	63.2	69.3	64.7	58.6	63.2
Inflation-adjusted	52.2	61.2	70.0	74.8	82.7	69.8	74.1	67.2	59.4	63.2
Southern										
Nominal	62.6	49.5	56.2	66.2	69.3	58.8	64.9	63.2	62.1	61.2
Inflation-adjusted	77.8	60.1	67.1	77.5	79.0	65.0	69.3	65.6	63.0	61.2

Source: GAO analysis of Forest Service data.

Note: Inflation-adjusted figures are in 2009 dollars.

Table 3 shows, for each research station, FS R&D spending using external funding from fiscal years 2000 through 2009, as well as the average annual change in funding during that period.

**Appendix III: Forest Service Research and
Development Spending and Personnel Data,
by Research Station**

Table 3: FS R&D Spending Using External Sources by Research Station, Fiscal Years 2000 through 2009

Dollars in millions

Research station	Fiscal years										Average annual change
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	
Forest Products Laboratory											
Nominal	\$1.9	\$2.2	\$1.6	\$1.8	\$1.7	\$1.8	\$1.6	\$1.0	\$1.6	\$2.8	4.4%
Inflation-adjusted	2.4	2.7	1.9	2.1	1.9	2.0	1.7	1.0	1.6	2.8	1.9
International Institute of Tropical Forestry											
Nominal	0.3	0.3	0.5	0.5	0.6	0.6	0.7	0.2	0.2	0.5	7.1
Inflation-adjusted	0.4	0.4	0.6	0.6	0.7	0.6	0.8	0.2	0.2	0.5	4.6
Northern											
Nominal	0.7	0.8	2.5	2.9	2.8	2.0	3.1	2.7	2.6	2.2	13.4
Inflation-adjusted	0.9	0.9	3.0	3.3	3.2	2.2	3.3	2.8	2.6	2.2	10.7
Pacific Northwest											
Nominal	3.7	1.7	2.8	3.2	4.6	4.7	5.5	5.0	3.3	3.1	-1.9
Inflation-adjusted	4.6	2.0	3.4	3.7	5.3	5.2	5.9	5.2	3.4	3.1	-4.2
Pacific Southwest											
Nominal	1.0	1.0	1.1	0.7	0.9	1.0	1.5	1.0	1.3	2.1	9.0
Inflation-adjusted	1.2	1.3	1.4	0.9	1.0	1.1	1.6	1.1	1.3	2.1	6.4
Rocky Mountain											
Nominal	6.2	10.0	13.7	16.0	15.7	17.0	21.6	22.0	19.9	18.8	13.0
Inflation-adjusted	7.8	12.2	16.3	18.7	17.9	18.8	23.1	22.8	20.2	18.8	10.3
Southern											
Nominal	1.2	1.7	1.6	1.9	2.2	1.6	2.1	1.7	1.5	1.5	2.9
Inflation-adjusted	1.5	2.1	1.9	2.2	2.5	1.7	2.3	1.8	1.5	1.5	0.5

Source: GAO analysis of Forest Service data.

Note: Inflation-adjusted figures are in 2009 dollars.

**Appendix III: Forest Service Research and
Development Spending and Personnel Data,
by Research Station**

Table 4 shows the amount of external funding provided to FS R&D from fiscal years 2005 through 2009, by source. Because other federal agencies provide the majority of external support to FS R&D, their contributions are shown by agency.

Table 4: Number of Projects Supported by, and Amount of, External Funding Provided to FS R&D, by Funding Source, Fiscal Years 2005 through 2009

Dollars in millions

External source		Fiscal years				
		2005	2006	2007	2008	2009
Federal						
Department of Agriculture	Projects	15	17	19	16	13
	Funding	\$2.1	\$1.7	\$1.9	\$1.6	\$0.8
Department of Commerce	Projects	1	3	3	2	3
	Funding	0.0	0.1	0.1	0.1	0.2
Department of Defense	Projects	12	40	33	34	35
	Funding	9.9	22.3	16.7	15.6	15.0
Department of Energy	Projects	5	5	6	5	8
	Funding	1.1	0.6	0.8	1.2	1.3
Department of the Interior	Projects	27	43	53	52	40
	Funding	5.0	4.9	4.5	6.2	5.1
Environmental Protection Agency	Projects	4	7	4	5	3
	Funding	0.7	0.4	0.5	0.2	0.2
National Aeronautics and Space Administration	Projects	1	5	6	5	8
	Funding	0.2	0.7	1.1	1.0	1.5
Other federal ^a	Projects	3	2	2	2	2
	Funding	0.8	0.0	0.0	0.0	0.2
Subtotal federal (number of projects)		68	122	126	121	112
Subtotal federal (funding amount)		\$19.7	\$30.6	\$25.5	\$25.9	\$24.2
Nonfederal						
Foreign	Projects	5	6	3	5	3
	Funding	\$0.1	\$0.4	\$0.1	\$0.2	\$0.3
Industry	Projects	19	42	46	30	29
	Funding	0.4	1.6	1.6	2.5	1.1
Nonprofit organizations	Projects	27	12	24	22	21
	Funding	4.3	0.3	0.8	0.7	0.7

**Appendix III: Forest Service Research and
Development Spending and Personnel Data,
by Research Station**

External source		Fiscal years				
		2005	2006	2007	2008	2009
States	Projects	16	18	19	22	26
	Funding	1.7	3.4	1.3	1.7	1.7
Universities	Projects	15	26	29	22	21
	Funding	0.4	0.8	1.1	0.7	0.7
Other nonfederal ^b	Projects	6	7	11	8	5
	Funding	0.2	0.3	0.4	0.3	0.3
Subtotal nonfederal (number of projects)		88	111	132	109	105
Subtotal nonfederal (funding amount)		\$7.1	\$6.8	\$5.3	\$6.0	\$4.8
Total (number of projects)		156	233	258	230	217
Total (funding amount)		\$26.8	\$37.4	\$30.8	\$31.8	\$29.1

Source: GAO analysis of Forest Service data.

^aAccording to Forest Service data, other federal sources of external funding include the U.S. Access Board, the Department of Health and Human Services, the Department of Homeland Security, the U.S. Postal Service, the Tennessee Valley Authority, the Department of Transportation, the Valles Caldera Trust, and the Department of Veterans Affairs.

^bOther nonfederal sources of external funding include cities, counties, tribes, local governments, and unidentified sources.

**Appendix III: Forest Service Research and
Development Spending and Personnel Data,
by Research Station**

Table 5 shows the number of FS R&D employees by employee type—permanent, term, and temporary—for each research station during fiscal years 2006 through 2009.

Table 5: Number of FS R&D Employees by Research Station, Fiscal Years 2006 through 2009

Research station	Fiscal year				Average annual change
	2006	2007	2008	2009	
Forest Products Laboratory					
Permanent	195	181	175	176	-3.4%
Term	8	5	3	2	-37.0
Temporary	14	12	11	16	4.6
International Institute of Tropical Forestry					
Permanent	44	42	41	45	0.8
Term	2	0	1	1	-20.6
Temporary	6	6	8	9	14.5
Northern					
Permanent	452	438	424	420	-2.4
Term	58	59	45	29	-20.6
Temporary	93	90	100	96	1.1
Pacific Northwest					
Permanent	297	300	285	299	0.2
Term	67	49	29	23	-30.0
Temporary	98	82	85	78	-7.3
Pacific Southwest					
Permanent	181	175	162	155	-5.0
Term	47	40	33	42	-3.7
Temporary	107	88	111	140	9.4
Rocky Mountain					
Permanent	406	391	381	373	-2.8
Term	85	72	63	48	-17.3
Temporary	124	127	112	164	9.8
Southern					
Permanent	424	430	403	407	-1.4
Term	35	30	24	19	-18.4
Temporary	113	94	90	74	-13.2

Source: GAO analysis of Forest Service data.

Appendix IV: Comments from the Department of Agriculture, Forest Service



Forest Service
Washington Office

1400 Independence Avenue, SW
Washington, DC 20250

File Code: 1420

Date: OCT 12 2010

Anu K. Mittal
Director, Natural Resources and Environment
U.S. Government Accountability Office
441 G. Street, N.W.
Washington, DC 20548

Dear Ms. Mittal:

Thank you for the opportunity to review and provide comment on the draft Government Accountability Office (GAO) Report entitled, "Forest Service Research & Development (R&D), Improvements in Delivery of Research Results Can Help Ensure that Benefits or Research Are Realized" (GAO-11-12). The report first recommended the Forest Service R&D assess the effectiveness of recent steps taken to improve science delivery from Forest Service R&D to land managers and other stakeholders. This includes the extent to which steps taken have helped ensure Forest Service R&D's work is disseminated beyond the agency. Moreover, it recommended we communicate more effectively with a broad range of potential stakeholders, including considering recommendations of the Forest Service's 2009 science delivery report. Secondly the report recommended we take steps to ensure individual performance assessments better balance various types of science delivery activities.

The Forest Service has reviewed the report and concurs with the report's observations and recommendations. The agency's comments on the two recommendations are as follows:

1. We will begin to assess the effectiveness of recent steps taken to improve science delivery, including considering recommendations made in the 2009 report on science delivery. We will also be committing additional resources to strengthen science delivery.
2. This specific finding was based on feedback from officials and users that R&D places greater emphasis on peer-reviewed journals as a means of science delivery than on other types of science delivery efforts, such as workshops, that are often more useful to end users. Forest Service R&D has various flexibilities within its authority to better focus the individual assessment process to improve science delivery, including:
 - a. Revising the internal Forest Service policy for Preparing Research Scientist Position Descriptions and Conducting Research Grade Evaluation Panels (dated 7/3/08). We will amend guidance to better emphasize other forms of science delivery and will add a seventh type of research accomplishment called science delivery;
 - b. Updating current internal training on the research panel process to include more emphasis on technology transfer and science delivery by providing several examples of ways to consider and evaluate all types of science delivery;
 - c. Continuing to recognize and provide incentives to scientists for science delivery through awards and performance bonuses for outstanding examples of science delivery.



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Ms. Anu K. Mittal

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However, there are certain factors within the research assessment process which we are required to follow by law, regulation, and federal government-wide policy, specifically Office of Personnel Management (OPM) requirements that federal scientists be evaluated against their classification standards, i.e., the Research Grade Evaluation Guide dated September 2006. While we can modify our internal guidance for conducting and evaluating Research Scientists, we are obligated to use and follow OPM's regulations and policies that apply to all federal Research Scientists.

If you have any questions, please contact Donna M. Carmical, Chief Financial Officer, at 202-205-1321 or dcarmical@fs.fed.us.

Sincerely,



 THOMAS L. TIDWELL
Chief

cc: Daina Apple, Angela Coleman, Sandy T Coleman, Jennifer McGuire, Donna M Carmical

Appendix V: GAO Contact and Staff Acknowledgments

GAO Contact

Anu K. Mittal, 202-512-3841 or mittala@gao.gov

Staff Acknowledgments

In addition to the individual named above, Steve Gaty, Assistant Director; Ulana Bihun; Ellen W. Chu; Carol Henn; Richard P. Johnson; Paul Kazemsky; Lesley Rinner; Kelly Rubin; Jacqueline Wade; Tama Weinberg; and Melissa Wolf made key contributions to this report.

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