Appendix 4

National Institute for Food and Agriculture Research

The National Institute for Food and Agriculture (NIFA) supports research, educational, and extension efforts in a wide range of fields related to agricultural and behavioral sciences. In all of these areas, NIFA works to solve challenges to agriculture—broadly defined to include forests and rangelands. The agency's history is largely tied to the establishment of land-grant

institutions and delivery of cooperative extension services to farmers, ranchers, and forest landowners.

This appendix reviews its programs and funding for forest-related science, based on a database that lists all NIFA grants. The funding amounts in the tables and graphs show the money provided by NIFA to the grant recipients; they do not include any matching funds. NIFA funding in nominal dollars has been adjusted to "real" dollars to account for price inflation over FY 2001–2014 using the domestic GNP deflators, base year 2009, from the Department of Commerce, Bureau of Economic Analysis.

Authorizing legislation

Morrill Land-Grant Act of 1862. NIFA's roots go back to the Morrill Land-Grant Act of 1862, which established "land-grant institutions" where working-class citizens could receive higher education, with a focus on farming and mechanical skills.[1] Subsequently, the Morrill Act of 1890 gave land-grant status to 20 historically black colleges, and in 1994, land-grant status was conferred on 29 Native American colleges.

Hatch Act of 1887. This act strengthened the capacity of land-grant universities to research agricultural problems. The Hatch Act funded land-grant colleges to create a series of agricultural experiment stations, laying a foundation for the cooperative extension services created by the 1914 Smith Lever Act Extension Act. To support and finance this mission, the U.S. Department of Agriculture (USDA) established the earliest predecessor to NIFA, the Office of Experiment Stations.

Smith-Lever Act of 1914. This act created a cooperative extension service associated with each land-grant institution. The partnership between agricultural colleges and USDA enabled the dissemination of information produced by the experiment stations' research.

[1] For example, in 1861, the first graduates from an American agricultural college graduated from what was then known as Farmer's High School, near Bellefonte, Pennsylvania. The next year, that school was renamed the Agricultural College of Pennsylvania, and with the passage of the Morrill Act, Pennsylvania selected the school to be the state's sole land-grant college. Today, this institution is known as the Pennsylvania State University.

Department of Agriculture Reorganization Act of 1994. This act merged the former Cooperative State Research Service and the former Extension Service into a single agency, the Cooperative State Research, Education, and Extension Service (CSREES). The merger made a single agency responsible for allocating funds and providing leadership in research, education, and extension.

Food Conservation and Energy Act of 2008. The 2008 Farm Bill established NIFA to take the place of the Cooperative State Research, Education, and Extension Service and address such 21st-century challenges as food security, climate change, natural resource and environmental sustainability, bioenergy, childhood obesity prevention, and food safety.

Today, NIFA is one of four agencies that make up USDA's Research, Education, and Economics mission area, alongside the Agricultural Research Service, the Economics Research Service, and the National Agricultural Statistics Service.[2] Each of the three other agencies has in-house researchers who conduct research and disseminate results, often partnering with researchers from universities and other areas. NIFA's approach is different. It makes grants that fund research, build capacity for research at land-grant institutions, and disseminate research results to landowners, land managers, companies, and investors.

NIFA grant programs for forest sector research

Some NIFA programs allocate funding via formulas intended to ensure that each eligible land-grant institution gets some funding each year. Examples of formula funding programs are the McIntire-Stennis and Hatch programs. Other programs are competitive, requiring individual researchers or teams to submit grant applications, which are reviewed against program criteria; projects with the greatest potential to advance science and meet program criteria are then funded.

Most programs require some level of matching funds from nonfederal sources, either in cash or in kind. Usually, the required match is 1:1, but some programs allow institutions to request a waiver, which usually reduces the match from 100 percent to 50 percent. Eligible

[2] In addition to these three intramural research agencies in the Research, Education, and Economics mission area, the Forest Service (in the Natural Resources and Environment mission area) also has an intramural research program.

institutions located in insular areas (American Samoa, Guam, Micronesia, Northern Marianas, Puerto Rico, and the Virgin Islands) are not required to match if the grant is below $200,000. Grant applicants must identify the proposed costs, the source of the match, and the value of any third-party in-kind contributions. Cost principles are spelled out in 2 CFR 200.

McIntire-Stennis program

This formula-funded program increases the capacity of universities to conduct forestry research in the production, utilization, and protection of forestland; to train future forestry scientists (e.g., graduate students); and to involve other disciplines in forestry research. Research topics include reforestation and land management to produce timber and other forest products; watershed management to improve conditions of water flow and protect against floods and erosion; land management to produce forage for livestock and improve habitat for wildlife; outdoor recreation; protection of forests and rangelands against fire and pests; utilization of wood and other forest products; and developing sound policies for managing forests and harvesting and marketing of forest products.

The McIntire-Stennis Act of 1962 created what is today the largest NIFA program focused on forests. It awarded $19.6 million in FY 2014. Since FY 2001, the McIntire-Stennis program has provided a total of $270.8 million. An annual base amount (approximately $25,000) is allocated to each state. Additional funding is provided via a formula-based ranking involving several factors:

- 40 percent of the program balance is allocated based on the state's area of nonfederal commercial forestland;
- 40 percent is allocated based on the volume of timber cut annually; and
- 20 percent is allocated based on the total expenditures for forestry research from nonfederal sources.

Funds are then distributed to eligible state-certified institutions.

Hatch program

Hatch formula-funded allocations cover a broad range of activities across all aspects of agriculture, including multiple-use forestry, urban forestry, agroforestry, wood utilization and wood products research, biotechnology, and rural and community development. Research may address problems of local, state, regional, or national concern. Some Hatch funds are designated for cooperative multidisciplinary research by a state agricultural experiment station, working with another state agricultural experiment station, the Agricultural Research Service, or a college or university, to solve problems of multistate concern. Nonfederal matching funds are required.

The Hatch program provided $5.9 million in FY 2014. Since FY 2001, the program has provided a total of $79.9 million, 62 percent of which went to forest, rangeland, and related natural resources research.

Evans-Allen program

This program supports research, dissemination of research results, and building and maintaining research infrastructure at 1890 land-grant institutions, including Tuskegee University and West Virginia State University. Matching funds from state governments are required. Since 2001, $5.1 million has been provided by the Evans-Allen program; 76 percent was devoted to forestry.

Other NIFA grants

Several relatively small competitive grant programs fund particular activities. An example is the 1890 Institution Teaching, Research and Extension Capacity Building Grants program, which supports research, teaching, and extension in all components of agriculture, including farm efficiency and profitability, ranching, renewable energy, forestry (including both urban and agroforestry), aquaculture, rural communities and entrepreneurship, human nutrition, food safety, family and consumer sciences, biotechnology, and conventional breeding. The program is intended to build and strengthen research, teaching, and extension capacity that advances fundamental sciences as well as translational research and development in support of agriculture, and also to coordinate opportunities to build on these discoveries at the 1890 land-grant universities.

Since FY 2001, a total of $93.1 million in "other grants" have been issued. Forest management and sustainability research received 27 percent, food and nonfood products research 23 percent, fire research 14 percent, and other natural resources research 3 percent.

National Research Initiative

The National Research Initiative (NRI) was the nation's primary merit-based peer-reviewed research response to challenges in food, fiber, forestry, and natural resource systems. Competitive, merit-based, peer-reviewed grants at USDA were first authorized by Congress in 1977. Congress provided $15 million to start the program. Any researcher was eligible to compete for a grant, whether from a university, federal or state agency, tribe, corporation, or a non-governmental organization.[3] From 1977 to 1989, the program grew to $40 million per year. In 1989, the National Research Council called for expanding competitive grants in a new program with proposed annual funding of $550 million.

Congress responded in the 1990 Food, Agriculture, Conservation, and Trade Act by authorizing annual spending up to $500 million on a new competitive grant program within five years. Congress initiated the NRI in FY 1991 with an appropriation of $73 million. Annual funding was increased to about $100 million in FY 1992 and remained at or near this level through FY 1998. In FY 1999, the NRI budget was increased to $120 million. Since its inception, the NRI has functioned as a pilot program to support high-quality research related to the nation's food, fiber, and natural resources systems. The program was terminated in FY 2008 and replaced by the Agriculture and Food Research Initiative (AFRI).

Agriculture and Food Research Initiative

AFRI, established by Congress in the 2008 Farm Bill, is the nation's premier peer-reviewed competitive grants program for fundamental and applied agricultural sciences. Grants are awarded to support research in six categories: plant health and production and plant products; animal health and production and animal products; food safety, nutrition, and health; bioenergy,

[3] Previous grant programs had certain eligibility restrictions, limiting the ability of employees from some non-university institutions from applying.

natural resources, and environment; agriculture systems and technology; and agriculture economics and rural communities.

Within these six categories, AFRI promotes research, education, and extension work that addresses problems of national, regional, and multistate importance. Funded projects within the "bio-energy, natural resources, and environment" category can target a wide range of topics, including under the broad umbrella of forestry, renewable energy from woody biomass, urban forestry, and agroforestry. These projects also create jobs and help develop the next generation of scientists in agriculture, forestry, range management, and products science.

A second component of the AFRI research portfolio are "integrated projects." Applications for an integrated project grant must address at least two of the three functions of agricultural knowledge—research, education, and extension—to ensure delivery of science-based knowledge and enable people to make informed practical decisions.

The AFRI portfolio includes Coordinated Agricultural Projects, which are large, multimillion-dollar projects that involve multiple institutions, and Food and Agricultural Science Enhancement grants, which help institutions become more competitive and attract new scientists and educators to careers in high-priority areas of agriculture.

The AFRI program has created a much larger pool of funding for competitive grants. It was initially authorized at a funding level of $700 million. In FY 2014, AFRI had a grants budget of $316.4 million. Of that total, $23.8 million was provided for projects directly contributing to forestry and $36.8 million for other natural resources subjects. Since FY 2010, AFRI has received $1.383.4 billion to advance research, education, and extension activities. This level of investment shows a gradual upward trend: a 21 percent increase from $262.4 million in FY 2010 to $316.4 million in 2014.

In 2012, NIFA asked the National Research Council to evaluate the recently established AFRI program. The subsequent report (NRC 2014) repeated made specific recommendations for AFRI organization and operation, among them:

- Emphasize fundamental research to support novel technologies, provide platforms for extension and education, and educate the next generation of scientists.

- Focus on foundational research, broader multidisciplinary approaches, and expanded interagency collaboration, including with the National Science Foundation, National Institutes of Health, Department of Energy, and National Aeronautics and Space Administration.
- Develop ways to encourage talented students to conduct research in the food and agriculture sector.
- Form a scientific advisory council, similar to the councils used by the National Institutes of Health and the National Science Foundation, to help validate program direction and changes in program structure.
- Simplify internal NIFA management of AFRI, such as by giving NIFA national program leaders a larger role in selecting peer-reviewed projects for awards.

NIFA leaders report that they are implementing many of these recommendations.

Small Business Innovative Research

Small Business Innovative Research (SBIR) is a government-wide, competitive grants program authorized by Congress in 1987. NIFA administers USDA's SBIR program. Funding is obtained through an assessment on the research and development programs of eight USDA agencies, including the Forest Service's Research & Development and the Agricultural Research Services. At the end of each fiscal year, these eight agencies total the amount of funding provided through research and development activities, including cooperative agreements and grants to outside organizations. In the subsequent fiscal year, they provide 3 percent of that total to the SBIR program. NIFA then issues a solicitation for grant applications from qualified organizations and makes the awards.

The program has provided funding for forestry and natural resources, as summarized in Table 1. Phase I is an exploratory phase where the technical merit, feasibility, and commercial potential of the proposed innovation are studied intensively. Up to $100,000 may be granted for 8 months of work during phase I. After peer review of the phase 1 results, the most promising innovation proposals can be funded for a second phase, which provides up to $600,000 over two years.

Table 1. Small Business Innovative Research funding for forestry and natural resources research, 1999–2016

Forestry area	*Total funding*	*Awarded applications*
Phase I	$8,817,886	106
Phase II	$20,583,415	61
Total	$29,401,301	167

Over the 14 years studied, forest resource management and sustainability received 31 percent of USDA's SBIR funding. Rangelands and grasslands, fire, and other natural resources received an additional 21 percent.

NIFA special grants

NIFA has 19 special grants programs, some of which accept forest or wood products research proposals. Examples include the Emerald Ash Borer and Sudden Oak Death programs, the Forest Products Research program, the Hardwood Scanning Center program, the Sustainable Engineered Materials/Renewable Resources program, and the Wood Utilization research program. Funding for all special grants programs was $16 million in FY 2009, but after the AFRI program started, funding dropped dramatically. In FY 2014, only $1.7 million in special grants was issued; forestry and wood products research received perhaps 50 percent of that.

NIFA's forest-related research funding

NIFA addresses seven broad knowledge areas (e.g., Natural Resources and Their Products) and 350 subjects of investigation. Fourteen of those subjects of investigation involve trees, forests, and forest products (excluding edible nuts). To simplify the following analysis, some aggregation of subjects was necessary. The addendum to this appendix provide more detail on NIFA's knowledge areas and subjects of investigation.

The NIFA database sorts grants by the subject of the investigation. This allows one to explore the amounts of funding in detail—for example, research on western conifers versus eastern broadleaved forests. For the purposes of this appendix, research is reported under the

subject of investigation by the type of forest—for example, western conifers afflicted by pests, rather than forest pests more generally. Similarly, funding for studies on forest economics and markets (the Economics knowledge area) is reported here by the specific subjects of those economic or market analyses, namely wood, paper, or woody biomass. Figure 1 shows the fine-scale subject categories related to forestry research. The effect of the major programmatic change in FY 2010, from formula funding to competitive grants, is apparent. (Some of the funding that would have been distributed in FY 2010 was carried over into FY 2011, resulting in a one-year bump-up in funding for various programs.)

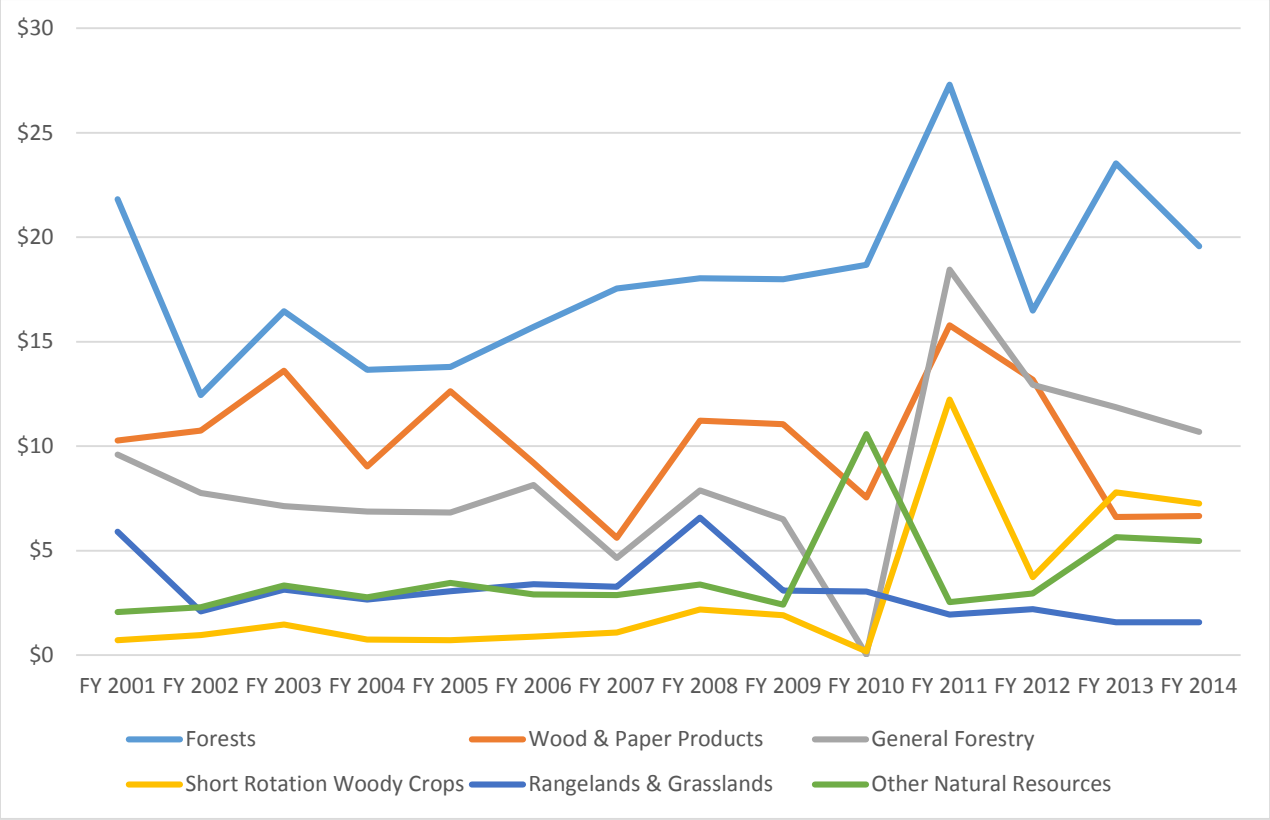

Figure 1. NIFA grant funding for natural resources programs, by subject of investigation, FY 2001–2014 (million constant dollars, base year 2009)

Over the 14 years analyzed, research related to western, northern, southern, and "other" forests received a total of 40 percent of the funding (Figure 2). (The "other" segment includes mixed conifer-broadleaved forests across all regions, plus grants for studies of tropical forests and chaparral.) "General" tree, forest, and forest products research and short-rotation woody

crops research increases that share to 66 percent. The three forest products research categories account for 23 percent of the total. The remaining subject areas got limited funding.

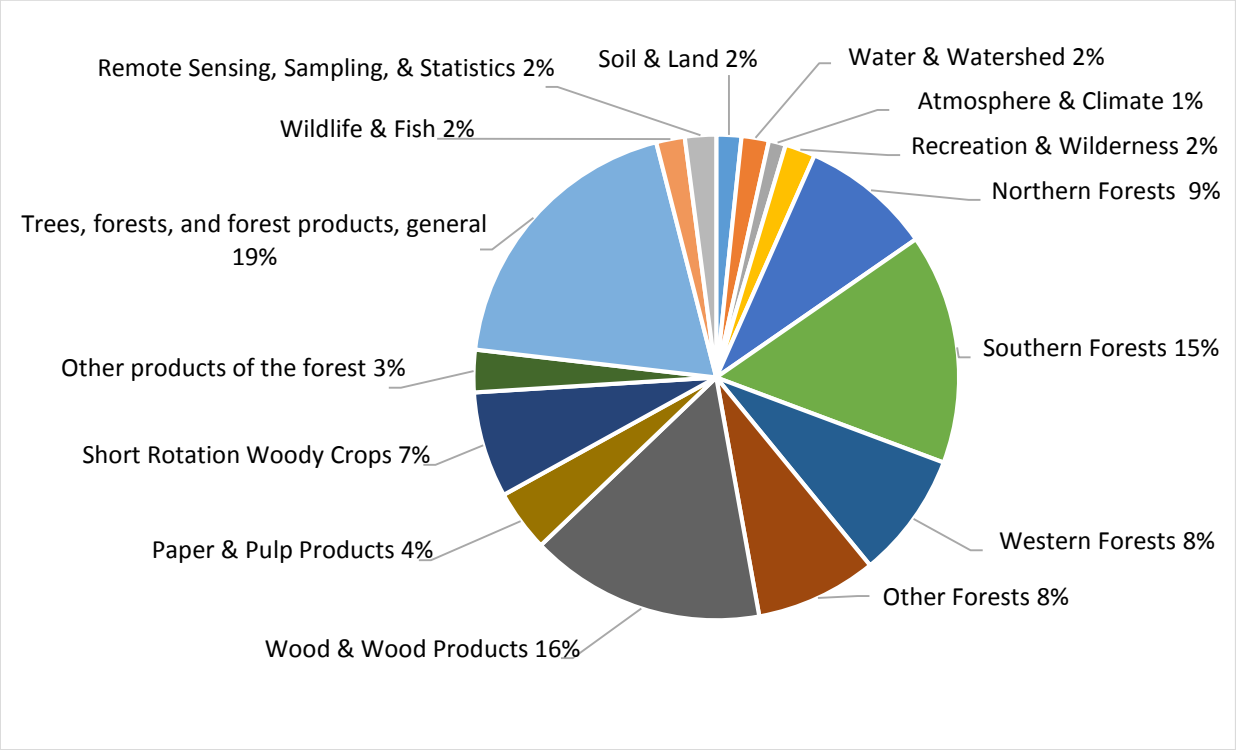

Figure 2. Allocation of NIFA grant funding by subject of investigation, FY 2001–2014

Figure 3 shows shifts in program emphasis over three time periods. The program's emphasis on wood and paper products research declined about $1 million annually between the first and last periods. Funding for other categories (except rangelands and grasslands) increased. The notable increase in research grants for short-rotation woody crops reflects USDA's response to the Biomass Research and Development Initiative, authorized by Section 9001 of the 2008 Farm Bill (see Appendix 6).

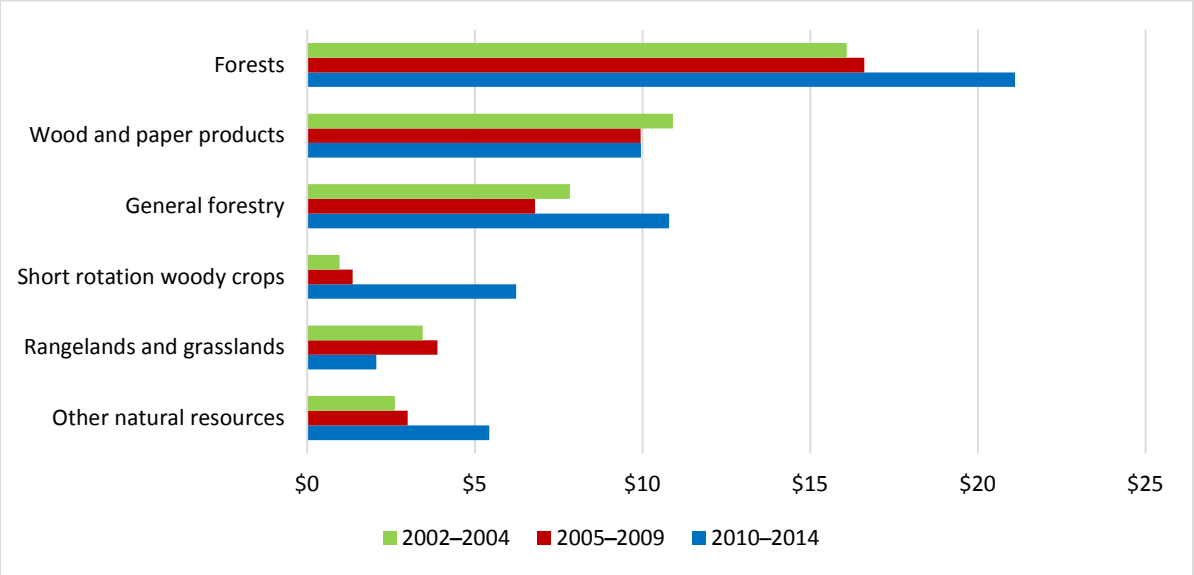

Figure 3. Average annual funding for all NIFA programs, by category, over three periods (million constant dollars, base year 2009)

The AFRI-NRI competitive grants program was responsible for the program increases observed for FY 2010–2014 (Figure 4). AFRI-NRI average annual funding for FY 2005–2009 was $7.8 million compared with $24.2 million for FY 2010–2014—an increase of $16.4 million (210 percent). Indeed, the increases in AFRI funding for FY 2010–2014 surpassed the increases in overall funding from all NIFA programs combined for forestry, general forestry, wood and paper products, and short-rotation woody crops, indicating that funding for these subjects of investigation declined in other programs besides AFRI-NRI.

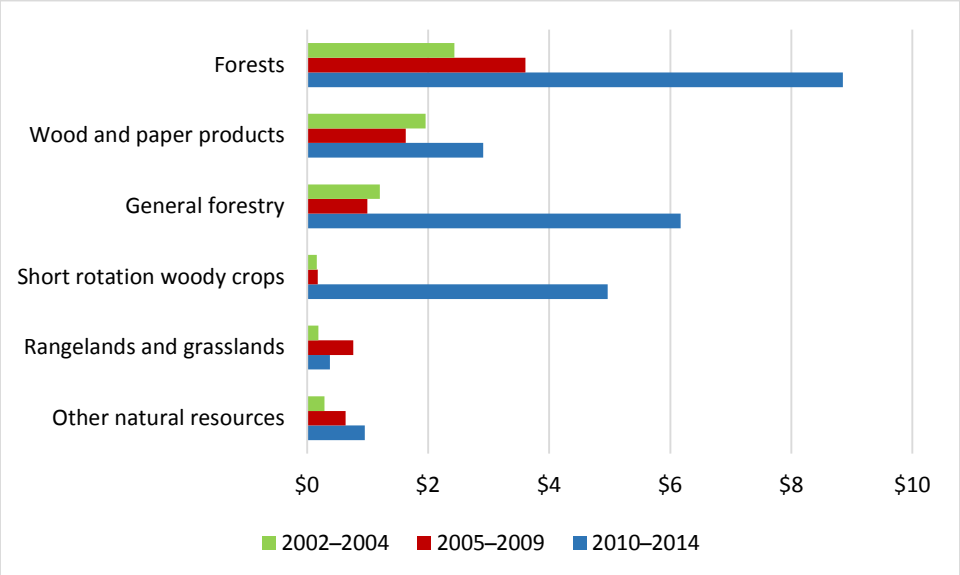

Figure 4. Average annual funding for AFRI-NRI, by category, over three time periods (million constant dollars, base year 2009)

In contrast to the big rises at AFRI-NRI, the average annual McIntire-Stennis formula funding for research in these six categories rose only $800,000 in real dollars (4.7 percent). The largest McIntire-Stennis program increases ($300,000 each) were in general forestry and other natural resources. The level of funding for wood and paper products was unchanged.

The SBIR funding reported in Figures 5 and 6 covers the two phases of this program. The data show both a gradual increase in funding and a higher number of research projects. In recent years, the amount of funding for phase II rose to $600,000, which increased the total funding for this area.

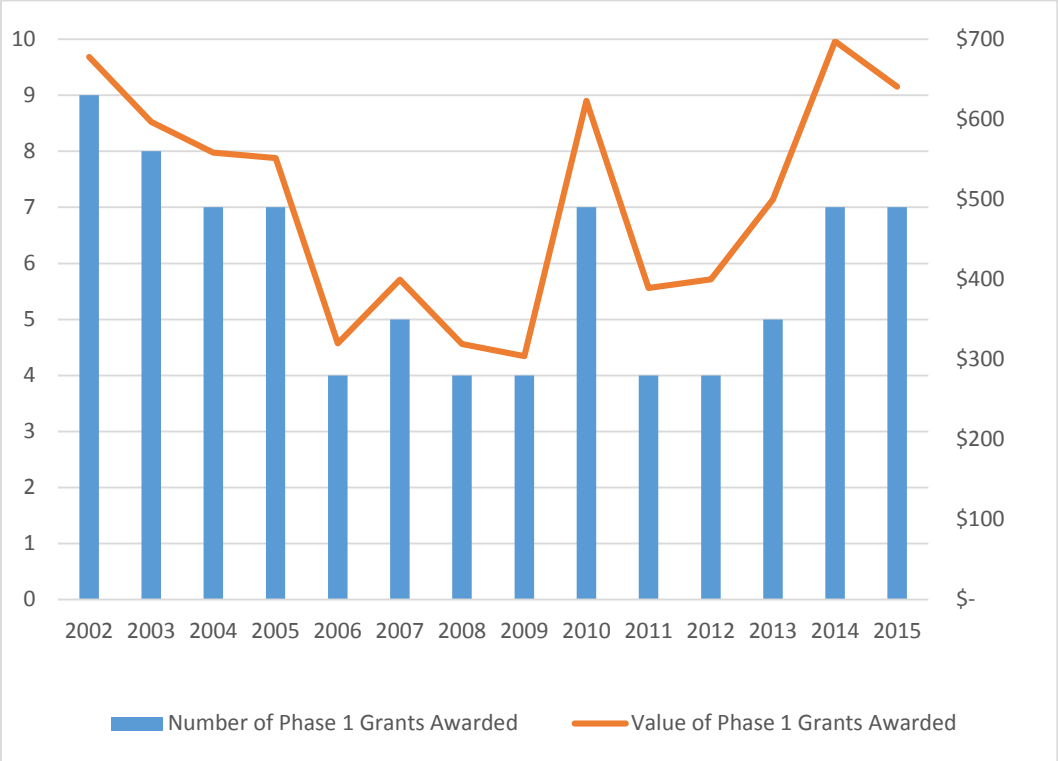

Figure 5. Small Business Innovation Research (SBIR) Phase I funding for forestry (topic 8.1), 2002-2015, (value of grants in thousands of actual dollars)

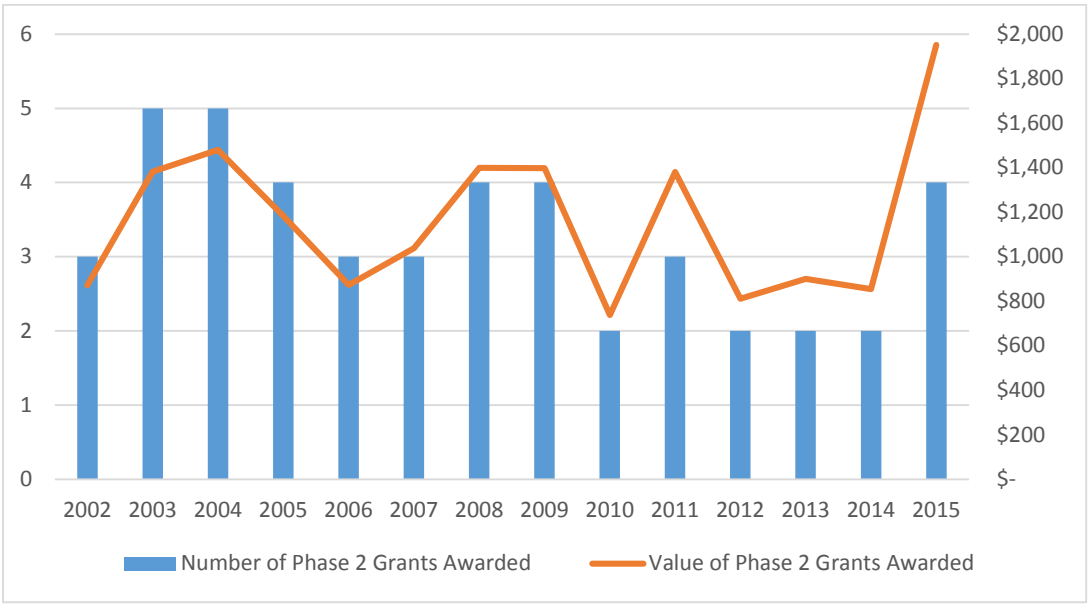

Figure 6. Small Business Innovation Research (SBIR) Phase 2 funding for forestry (topic 8.1), 2002-2015, (value of grants in thousands of actual dollars)

AFRI has begun funding large continuation grants of $10 million to $50 million for research in the bioenergy and climate change areas. Some of these large grants involved forestry, but the NIFA database doesn't identify these grants by that category.

Discussion: Formula funding versus competitive grants

Formula-funded programs (also called capacity funding) were responsible for growing the nation's research capacity in forestry and agriculture. From the 1887 Hatch Act to the 1962 McIntire-Stennis Act and the Evans-Allen Act of 1977, the consistency of annual formula funding helped institutions develop the capacity to teach, conduct research, develop new products and technologies, and disseminate results.

In 1995, the National Research Council reported, "The structure of federal support for research at colleges of agriculture is shifting away from fixed formulas toward competitive grants based on scientific merit and special grants earmarked by Congress" (NRC 1995, p. 76). That statement was based on an analysis of funding from 1972 to 1992 for the 1862 state agricultural experiment stations and forestry schools and the 1890 institutions. Although funding increased substantially over those two decades, federal funding by formula dropped from 58 percent to 33 percent of the total across all three categories of institutions; for forestry schools alone, it fell from 47 percent to 21 percent. But it took another decade and the creation of AFRI for a more dramatic shift to occur (Figure 7, orange bars).

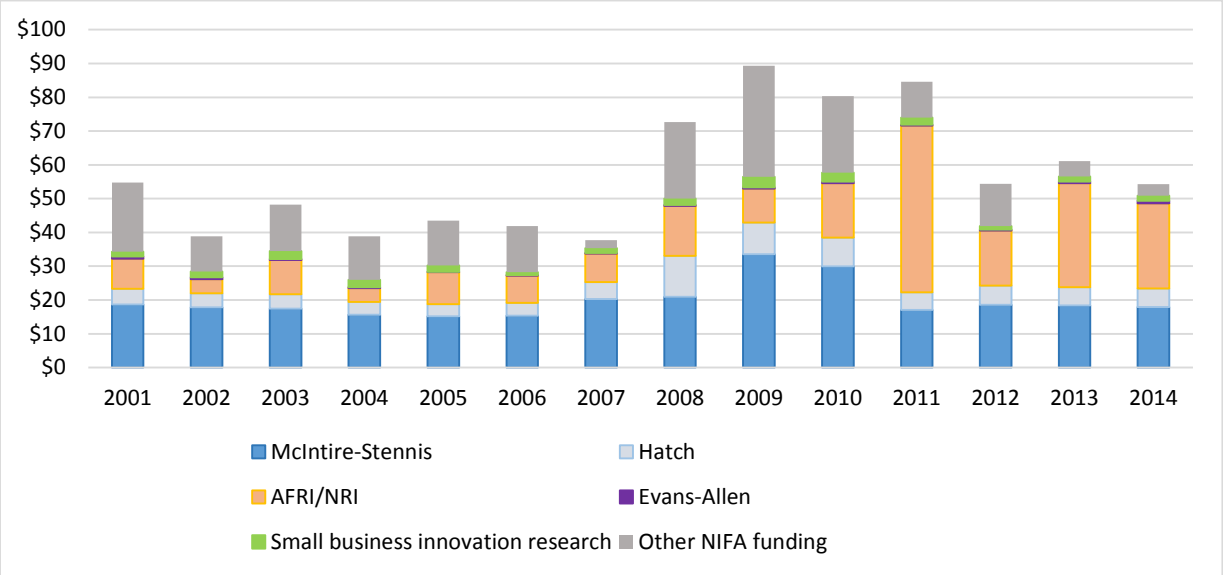

Figure 7. Total NIFA grant funding, by program and year (million constant dollars, base year 2009)

In the late 1990s the benefits of distributing federal funds via formulas versus competitive grants became a subject of debate in both the executive and legislative branches. The USDA programs most debated at that time were NIFA's formula-funded programs—the McIntire-Stennis, Hatch, and Evans-Allen programs.

In 2012, the President's Council of Advisors on Science and Technology (PCAST) issued "Report to the President on Agriculture Preparedness and the Agriculture Research Enterprise." The report noted that some universities chose to distribute McIntire-Stennis funds competitively among their faculty, while others used the funds for permanent faculty salaries. PCAST noted that the latter option, "where funds are guaranteed regardless of outcomes, could unintentionally dissuade researchers from the challenging work of performing at the cutting edge of science and ultimately producing novel, innovative research. Historically, some uses of these formula funds have been critiqued for not efficiently stimulating high quality" (PCAST 2012, p. 30). Forestry school deans and department heads acknowledge that in many institutions, including 1862, 1890, and 1994 schools, the McIntire-Stennis program has funded 25 to 35 percent of faculty salaries.[4] In a program with 10 or 12 faculty, that means three to five faculty positions depend on McIntire-Stennis. Thus the program supports not only research but also instruction that is likely

[4] Personal communication with members of the National Association of University Forest Resources Programs (NAUFRP) at deans' and department heads' meetings, October 2015 to November 2016.

essential to the curriculum and continued accreditation. It also provides money for graduate student research, growing the next generation of scientists. These benefits of formula-funded programs, though difficult to quantify, are part of the foundation for forest sector research.

The PCAST report reiterated the call for shifting funding allocations from formulas to competitive mechanisms, citing National Research Council reports from 1972, 1989, 2000, and 2003, and made it the first recommendation: "PCAST recommends that the focus of USDA research funding shift towards competitive grants, gradually rebalancing the research portfolio for intramural funding and funding for land grant institutions to incorporate incentives for innovation consistent with other research agencies across the Federal Government" (p. 40). The report had noted that funding for competitive research was low in USDA research agencies (Agricultural Research Service, Economic Research Service, Forest Service, National Agricultural Statistics Service, and NIFA), amounting to only 16 percent of appropriations, primarily because the agencies (NIFA excepted) had large intramural research programs. Therefore, PCAST recommended that the rebalancing occur through boosting AFRI funding to $500 million annually. PCAST also recommended boosting National Science Foundation funding for basic agricultural science from an estimated $120 million to $250 million in FY 2014.

Huffman et al. (2006, p. 269) reported on the shift: "From 1980 to 2003, the USDA-administered federal formula funds declined by 57% or $124 million. Over this time period, NRI appropriations increased by $120 million, but less than 40% of NRI funds go to State agricultural experiment stations. … Hence, CSREES funding for State agricultural experiment stations has fallen dramatically over the past 25 years." The article then highlighted several consequences:

- Competitive grant program managers set the research agenda from a national perspective. Yet many important problems are local or regional. Reducing formula funds may make it difficult to target research on local issues important to local interests. Further, research and extension faculty will spend much more of their limited time writing grant proposals, and less time actually doing research or interacting with farmers and other landowners.
- Increased uncertainty about receiving grants coupled with shorter-run priorities in grant programs and the need to show positive outcomes inhibit long-term research. The need to show positive outcomes on short-term grants is likely to focus that work on topics with

more predictable outcomes rather than high-risk projects whose outcomes are uncertain. When successful, however, the higher-risk research often leads to breakthroughs that have much higher payoffs in the long run.

- Formula funds provide flexibility for state universities to respond more quickly to emerging crises. Further, the research can be focused on high payoffs for locally important crops.
- Competitive grant programs have much higher internal program administration and transaction costs. Those costs are not only financial but also include much higher time investments for researchers who prepare grants and for researchers who review grant proposals. Historical evidence suggests that formula funds can be administered at 5 to 12 percent of appropriations; a competitive grant program's indirect costs are two to four times that percentage, when both the federal agency and university administrative costs are accounted for.

As evidence that formula-funded research is productive, Huffman cited previous work finding a social rate of return on public agricultural research of about 50 percent. He also found that shifting from formula-funded to competitive grant programs would lower the benefits of research and its rate of return.

A second major theme of the PCAST (2012) report was that formula funding to forestry schools at land-grant universities may not be tapping into the research, development, and innovation expertise:

> One of the drawbacks of the current system of agricultural research is that there is often a separation of agricultural research from other areas of biology, chemistry, social sciences, earth sciences, computer sciences, and engineering. Although it is understandable that the land grant universities play a leading role in the agricultural research enterprise, it is essential that other research universities participate in the effort to address these challenges, allowing the agricultural research enterprise to benefit from the substantial public investments in basic research in other areas. … At times, this apparent fragmentation between agricultural research and sustained interaction with other basic sciences at the university level can perhaps prevent or

> delay the transfer of knowledge and discovery, ultimately delaying the agricultural gains that are needed. (pp. 30–31)

The rationale for PCAST's recommendation was that basic science underlies many of the innovations in bioenergy and other new projects, and shifting from formula funding to competitive grants would enable researchers outside forestry schools to obtain funding.

The Agriculture Act of 2014 altered matching funding requirements for certain NIFA competitive grant programs. See https://nifa.usda.gov/new-matching-requirement-table for an analysis of new matching fund requirements.

Conclusions

This review of forestry-related research in programs of the National Institute for Food and Agriculture suggests a few observations.

Creation of AFRI has funded research important to the forest sector. AFRI's large increase in funding, to $316 million, has made more money available for research and development. Despite the overall funding increase, however, the relatively small share given to forestry proposals is of concern: researchers, developers, and innovators in the forest sector received 7.5 percent ($23.8 million) in FY 2014. Much of this money is funding multiyear research proposals that are still underway, so findings are limited.

AFRI funding for forestry leans toward topics helpful to landowners, not industry. Of the $23.8 million in FY 2014 that went to forestry, broadly defined, about two thirds ($15.7 million) went to land management, ecological, and general forestry research—an investment that will help private forest landowners and public land managers. Wood utilization and pulp and paper research received $5 million, of which $2.95 million supports the loblolly pine genome project. That leaves just $2 million for wood utilization and pulp and paper projects—research with the potential to stimulate innovation and investment in forest industries, leading to more jobs in rural areas and more stable rural communities. (The remaining $6.1 million went to short-rotation woody crops research.)

Funding for short-rotation woody crops has opened new commercial possibilities. The 2008 Farm Bill made renewable bioenergy a focus, and the PCAST and National Research Council reports recommended funding research that would lead to new products, including bioenergy. AFRI's $6.1 million for short-rotation woody crops research aims at improving biofuels production and, more broadly, energy security. It also helps support the Biofuels Research and Development Initiative, a research program in partnership with the Department of Energy's biofuels research program. A recent product of this work was the first cross-country flight (Seattle to Washington, D.C.) by Alaska Airlines using jet fuel produced from woody biomass.

Whereas biofuels based on crop production, such as corn-based ethanol, can distort food supply chains, developing biofuels from woody biomass—which exists in large quantities on private forestland—would distort existing wood markets. Many regions of the country have an abundance of low-quality trees that cannot pay their way out of the woods because they are unsuitable for lumber and most other wood products. Private landowners therefore have no market incentives to manage and improve their forests. Innovative biofuels processes can help create demand for low-quality wood and provide an economic return to private landowners, thereby encouraging better management and discouraging conversion of forests to other land uses.

The shift to competitive grant programs has eroded the foundation for forestry research and education. The PCAST and National Research Council reports presented valid reasons to emphasize competitive grants, but the importance of the McIntire-Stennis program to land-grant universities' forestry programs has been largely overlooked. Formula funding has supported several generations of forest and wood products researchers over the past 50 years, and the program continues to support faculty members who teach undergraduates and are essential for forestry schools' accreditation. Competitive grants fund graduate studies and graduate research but offer little support for undergraduate education.

AFRI's program description and requirements for proposals suggest that NIFA is seeking ways to advance some of the original McIntire-Stennis program objectives, such as providing grants for graduate students and requiring that research projects include dissemination, communication, or extension activities. AFRI also welcomes research proposals that have

multiple institutions and other organizations as partners, and proposals that deal with regional issues. This effort to broaden AFRI to include many of the long-standing elements of the McIntire-Stennis program is recognized as a positive attribute.

But by definition, competitive grants introduce uncertainty about whether funding will actually be forthcoming, and this uncertainty—in contrast to formula funding—makes it more difficult for deans and department heads to manage educational and research programs. Failure to receive a competitive grant can interrupt progress toward AFRI objectives, wasting effort as programs cycle through startup-stop-restart modes when grants are interrupted. For worthy social goals that have long-term benefits for the forestry profession, such as recruiting undergraduates from diverse backgrounds, it is not clear whether the AFRI program's competitive grants will lead to better outcomes.

During the Great Recession of December 2007 to June 2009, states reduced their funding for state universities—by more than 20 percent in 37 states, in terms of dollars per student.[5] In Louisiana and South Carolina, both important states for forestry and forest industry, higher education funding per student dropped by more than 40 percent. In Oregon, Idaho, Alabama, Pennsylvania, and New Hampshire, the cuts were greater than 30 percent. In response to these reductions, universities eliminated faculty positions, put off infrastructure investments, and raised tuition. Forestry programs, which are often more expensive to offer than, for example, liberal arts curricula because they require laboratories and school forests for teaching and research, were stressed. Today, average state funding per student is still 23 percent below the prerecession level. And when state support for higher education plummets and forestry programs are threatened, the importance of formula programs like McIntire-Stennis grows.

Meanwhile, the 2008 Farm Bill made 1890 land-grant institutions eligible to receive McIntire-Stennis funding, raising the number of institutions participating in the program from 65 to 78. Because McIntire-Stennis funding from FY 2010 to 2014 was relatively stable, expanding the number of eligible institutions by 20 percent meant that the share received by the 1862 institutions declined. Thus, sustaining forestry education for undergraduate and graduate students—-the pipeline of the next generation of researchers—has become more difficult.

[5] http://www.cbpp.org/research/states-are-still-funding-higher-education-below-pre-recession-levels.

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Addendum 1

Supporting data

Table A1. NIFA funding for projects whose key words include "forestry," by topic and fiscal year, 2001–2014 (thousand nominal dollars)

Topic	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*
Forest resource management and sustainability	$16,833	$14,838	$19,274	$15,884	$19,290	$17,954	$16,507	$26,688	$41,306	$33,566	$44,786	$21,073	$33,306	$31,218
Plant production and protection	$8,751	$4,190	$5,018	$4,068	$4,206	$6,388	$7,031	$11,482	$16,128	$16,526	$13,369	$9,424	$12,004	$9,046
Food and nonfood products	$5,742	$4,924	$5,793	$4,734	$7,139	$4,660	$3,874	$9,596	$11,052	$12,524	$16,080	$14,176	$8,131	$8,133
Range resource management	$6,039	$2,384	$3,374	$3,402	$3,321	$4,044	$3,946	$0	$6,890	$6,808	$2,159	$3,085	$2,952	$2,816
Management and control of fire	$2,515	$957	$1,443	$2,151	$2,433	$1,571	$1,496	$16,920	$2,151	$2,008	$1,152	$1,543	$1,353	$991
Other natural resources	$1,609	$1,860	$2,239	$1,810	$1,255	$1,618	$1,851	$3,689	$5,902	$4,683	$2,546	$3,612	$2,449	$2,206

Economics, markets and policy	$2,227	$1,998	$2,097	$1,430	$1,451	$2,246	$1,177	$1,440	$3,486	$2,689	$1,358	$1,810	$2,511	$1,704
Agriculture, natural resource, and biological engineering	$1,770	$1,626	$2,318	$956	$924	$1,260	$698	$1,701	$1,552	$1,652	$2,641	$1,519	$901	$782
Program and project support and administration	$132	$114	$186	$167	$118	$183	$207	$376	$478	$480	$3,459	$832	$1,825	$2,124
Families, youth, and communities	$435	$259	$137	$190	$78	$9	$30	$159	$298	$424	$252	$122	$65	$11
Human nutrition, food safety, and human health and well-being	$7	$35	$125	$134	$204	$41	$36	$193	$224	$234	$118	$429	$232	$270
Animal production and protection	$84	$111	$81	$59	$43	$94	$94	$302	$58	$346	$22	$27	$7	$0
Fiscal year total	$46,144	$33,296	$42,085	$34,985	$40,462	$40,068	$36,947	$72,546	$89,525	$81,940	$87,942	$57,652	$65,736	$59,301

Table A2. NIFA funding, by subject of investigation and fiscal year, 2001–2014 (*thousand nominal dollars)*

Subject of investigation	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*
Forests	$18,373	$10,660	$14,375	$12,293	$12,846	$15,018	$17,189	$18,001	$18,022	$19,038	$28,366	$17,469	$25,335	$21,384
Wood and paper products	$8,646	$9,203	$11,892	$8,129	$11,756	$8,799	$5,496	$11,196	$11,066	$7,696	$16,411	$13,963	$7,111	$7,283
Short rotation woody crops	$602	$817	$1,273	$672	$669	$850	$1,056	$2,179	$1,918	$176	$12,703	$3,955	$8,390	$7,925
General forestry	$8,077	$6,645	$6,228	$6,186	$6,347	$7,784	$4,549	$7,872	$6,514	$29	$19,172	$13,703	$12,767	$11,675
Rangelands and grasslands	$4,980	$1,791	$2,736	$2,391	$2,851	$3,245	$3,210	$6,574	$3,097	$3,095	$2,013	$2,333	$1,696	$1,724
Other natural resources	$1,737	$1,967	$2,911	$2,490	$3,214	$2,772	$2,809	$3,378	$2,421	$10,785	$2,636	$3,117	$6,075	$5,977
Crops and plant science	$1,234	$1,111	$1,165	$1,152	$1,584	$1,149	$879	$1,318	$1,308	$2,351	$1,874	$1,093	$974	$1,031
Animals and animal products	$1,821	$394	$494	$447	$258	$355	$180	$305	$325	$0	$250	$359	$209	$529
Other agricultural research	$663	$707	$1,060	$1,279	$2,821	$2,012	$1,603	$1,802	$1,368	$0	$4,630	$1,720	$3,182	$2,644

Addendum 2

NIFA research database categories

NIFA classifies research using a detailed hierarchy. Classification details are described in the *Manual for Classification for Agricultural and Forestry Research, Education, and Extension.* The latest version is Revision VIII, issued in April 2013 and available at http://www.cris.nifa.usda.gov/manualviii.pdf. For this review, two different ways were used to search the database: (1) by topic and knowledge area; and (2) by subject of investigation.

Nine topics are the highest-level categorization in the NIFA database. The second level consists of 84 knowledge areas. The topic Natural Resources and Environment has 18 knowledge areas, listed below. Grants data for knowledge areas 121–125 (shown in **orange)** were extracted from the database for this report. If the abstracts and/or key words indicated supplementary knowledge areas, these were also reported. Hence, Table A1 in Addendum 1 demonstrates where these knowledge areas were cross-classified with other knowledge areas. For purposes of further analysis in this review, areas 123, 124, and 125 were combined into a single cluster called "Forest Management and Sustainability.

- Topic: Natural Resources and Environment
    - 101. Appraisal of Soil Resources
    - 102. Soil, plant, Water, Nutrient Relationships
    - 103. Management of Saline and Sodic Souls and Salinity
    - 104. Protect Soil from Harmful Effects of Natural Elements
    - 111. Conservation and Efficient Use of Water
    - 112. Watershed Protection and Management
    - 121. Management of Range Resources
    - 122. Management and Control of Forest and Range Fires
    - 123. Management and Sustainability of Forest Resources
    - 124. Urban Forestry

- 125. Agroforestry
- 131. Alternative Uses of Land
- 132. Weather and Climate
- 133. Pollution Prevention and Mitigation
- 134. Outdoor Recreation
- 135. Aquatic and Terrestrial Wildlife
- 136. Conservation of Biological Diversity
- 141. Air Resource Protection and Management

A second way to classify data in the NIFA database is by subject of investigation. The subject areas printed in **gold** below were combined into a class called Other Natural Resources; the subject areas shown in **purple** were combined into Wood and Paper Products; and the subject areas shown in **green** are classified under Forests. Within the Natural Resources and Their Products subject area are the following subjects of investigation:

- Soil and Land (3 subordinate categories)
- Water Resources, Watersheds and River Basins (5 subordinate categories)
- Atmosphere, including Climate and Weather (5 subordinate categories)
- Recreational Resources, including Wilderness (4 subordinate categories)
- Rangelands and Grasslands (6 subordinate categories)
- Wildlife and Natural Fisheries Management, Endangered Species (10 subordinate categories)
- Trees, Forests, and Forest Products (excluding edible nut crops) (14 subordinate categories)
  - 0610. Conifer forests of the North
  - 0611. Conifer forests of the South
  - 0612. Conifer forests of the West
  - 0613. Mixed conifer-broadleaf forests
  - 0620. Broadleaf forests of the North

- 0621. Broadleaf forests of the South
- 0622. Broadleaf forests of the West
- 0630. Chaparral and shrub lands
- 0640. Tropical forests
- 0650. Wood and wood products
- 0660. Paper and pulp derived products
- 0670. Short rotation woody crops, including holiday trees
- 0680. Other products of the forest
- 0699. Trees, forests, and forest products, general

All other information was collapsed into its subject area, such as Crops and Plant Science. This resulted in the following set of subject classes used in the review:

- Forest Management and Sustainability
- Wood and Paper Products
- Short Rotation Woody Crops
- General Forestry
- Rangelands and Grasslands
- Other Natural Resources
- Crops and Plant Science
- Animals and Animal Products
- Other Agricultural Research