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U.S. Public Agricultural Research

Changes in Funding Sources and Shifts in Emphasis, 1980-2005

David Schimmelpfennig and Paul Heisey

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Changes in Funding Sources and Shifts in Emphasis, 1980-2005

David Schimmelpfennig and Paul Heisey

Abstract

Over the years, proposals have recommended shifting the focus of public agricultural research from applied to basic research, and giving higher priority to peer-reviewed, competitively funded grants. The public agricultural research system in the United States is a Federal-State partnership, with most research conducted at State institutions. In recent years, State funds have declined, USDA funds have remained fairly steady (with changes in the composition of funding), but funding from other Federal agencies and the private sector has increased. Efforts to increase competitively awarded funds for research have fluctuated over time, as have special grants (earmarks). Along with shifts in funding sources, the proportion of basic research being undertaken within the public agricultural research system has declined. This report focuses on the way public agricultural research is funded in the United States and how changes in funding sources over the last 25 years reflect changes in the type of research pursued.

Keywords: Agricultural research, Current Research Information System, CRIS, State Agricultural Experiment Stations (SAES), competitive and formula funds

Acknowledgments

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Contents

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Summary

Public agricultural research has been a major contributor to advances in agricultural productivity that have led to abundant and affordable food and fiber in the United States. A period of sustained growth in public agricultural research-and-development (R&D) investment that began in the 1930s ended in about 1980, with smaller and more variable increases observed since that time. Private investment in agricultural R&D surpassed public investment for the first time in 1980. The slowdown in public research funding growth has coincided with new demands from consumers and taxpayers for environmental and food safety advances based on public research.

What Is the Issue?

The public agricultural research system in the United States is a Federal-State partnership. The Federal Government funds intramural research through USDA agencies such as the Agricultural Research Service (ARS) and extramural research at State institutions such as the State Agricultural Experiment Stations (SAES), which are located at land-grant universities. SAES are also funded by State legislative appropriations, a variety of private sources, including industry funding, and Federal agencies other than USDA.

This decentralized State-led structure has resulted historically in geographically specific applied research. Policy proposals in recent decades have recommended shifting the focus of public agricultural research to more basic research, giving higher priority to peer-reviewed, competitively funded grants. The 2008 Food, Conservation, and Energy Act (Farm Act) created the National Institute for Food and Agriculture to coordinate USDA's agricultural research funding.

What Did the Study Find?

Real public agricultural research spending—that is, spending from all funding sources adjusted for inflation—fluctuated but remained basically level from 1980 through the mid-1990s, then fluctuated. In the late 1990s, SAES funding from Federal sources outside of USDA as well as non-Federal sources continued to increase. Federal intramural funding of ARS research leveled off.

Funding levels from the various sources that support public agricultural research have changed since 1980. Funding sources include State appropriations, formula funds, and competitive and special grants, but also include support provided by the private sector. In inflation-adjusted terms, shifts in funding from these various sources have resulted in constant or slowly increasing overall expenditures on public agricultural research:

- USDA funds intended for the States, administered by the Cooperative State Research, Education, and Extension Service (CSREES), have remained essentially constant in real terms since 1980. However, the composition of CSREES funds has changed over time:

- ❑ Formula funds declined in real terms by about half over the 1980-2005 period. These funds are based on statutory formulas governed by legislation.
- ❑ Competitive grant funding rose in real terms, more than quadrupling by the mid-1990s, and has fluctuated since that time. Peer-reviewed competitive grants are awarded in response to proposal requests.
- ❑ Special grants (Congressional earmarks) rose by 250 percent in real terms until the mid-1990s, fell through 2001, and then rose again.
- ❑ Other CSREES-administered funds have risen the most rapidly of all research funding in real terms since the late 1990s.

- Grants from other Federal agencies, like the U.S. Department of Energy, the National Institutes of Health, and the National Science Foundation, to SAES and other cooperating institutions more than tripled in real terms from 1980 through 2005. Funding from these non-USDA sources is now nearly as large as the funding obtained from private companies and SAES sales of research byproducts.

- State agreements with private companies and commodity organizations, sales of products and intellectual property, and other non-Federal sources of funds have grown continuously in real terms since 1980.

USDA intramural research expenditures have fluctuated, especially at ARS. Intramural spending (by USDA agencies on inhouse research) declined slightly in real terms from 1980 to the late 1990s, before returning in real terms to its 1980 level. Most of this pattern can be explained by expenditure trends at ARS. The number of ARS scientists, which had been declining, rose with this increase in spending, but not enough to match the 1980 number.

CSREES funding of basic research has declined. Of the three main CSREES funding instruments for which detailed data are available, competitive grants are directed more toward basic research than are formula funds, and formula funds are directed more to basic research than are special grants. CSREES has been viewed as setting the direction of extramural public agricultural research, particularly because of the matching funds supplied by State legislatures. This perception exists even though all CSREES funding going to the States currently accounts for only a little over 10 percent of all public agricultural research expenditures. Although Federal support might be expected to favor basic research, instead:

- The percentage of agricultural competitive grants devoted to basic research fell from 76 percent to 65 percent from 1998 to 2003.

- Over the same period, the total amount of formula funds declined in real terms as the percentage of those funds devoted to basic research remained at about 40 percent.

- Although the percentage of CSREES special grants going to basic research increased slightly, the percentage of funding devoted to basic research fell for CSREES as a whole.

Since private agricultural input companies tend to focus their research on near-market research, it can be assumed that industry funding is usually directed more toward applied research than basic research, doing little to offset other reductions in basic research. USDA intramural research is divided roughly equally between basic and applied topics.

How Was the Study Conducted?

This report focuses on how agricultural funding mechanisms changed between 1980 and 2005; the years when comparable data are available. The Current Research Information System (CRIS), National Science Foundation, and USDA agency budget directors supplied the data required to address patterns of public research funding. Economic Research Service researchers had previously developed a research deflator that was updated for this project and used to convert nominal dollars to real constant dollars.

Expenditures from CSREES funds in 1998 and 2003 (years for which data on research topics are comparable) were analyzed following specialized queries to the CRIS system. This allowed disaggregation not available in published reports. This analysis determined the division between basic and applied/developmental research by funding instrument and research topic for CSREES funding of State institutions. The division between basic and applied/developmental research for ARS was supplied by the ARS budget office.

Introduction

Advances in agricultural productivity have led to abundant and affordable food and fiber throughout most of the developed world. More efficient agricultural machinery, agricultural chemicals and fertilizers, genetic improvements in crops, and changes in farm management techniques have transformed U.S. agriculture since the Great Depression and set the stage for continued productivity growth. Agricultural research funded by both public agencies and private-sector firms has been the most important source of these advances. Studies consistently find high social rates of return from public agricultural research, with median rates exceeding 40 percent (Alston et al., 2000; Evenson, 2001). Even when adjustments are made for such factors as private-sector research, losses from tax collection, and errors in research lag estimates, rates of return to public research remain positive (Fuglie et al., 1996).

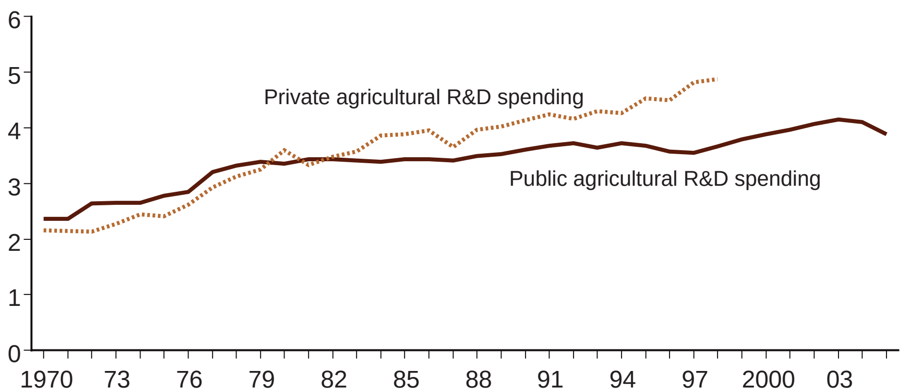
The environment for U.S. public agricultural research changed over the past 30 to 40 years. Private-sector investment in agricultural research and development (R&D) in the United States grew rapidly from the middle 1970s to the present, and surpassed public-sector investment by the early 1980s. The rate of increase in total public-sector agricultural research expenditures slowed during the same time period (fig. 1).[1] Meanwhile, government and private-foundation reports noted that both public-sector agricultural research and mission-oriented government agencies had become more focused on applied research rather than on basic research (National Academy of Sciences, 1972; Rockefeller Foundation, 1982; National Research Council, 1996). These reports also recommended a shift in funding mechanisms toward more use of competitive allocation rather than formula funding of State Agricultural Experiment Stations (SAES).

Debates over the direction of public agricultural research and the nature of its funding mechanisms have continued (Alston and Pardey, 1996; Fuglie and Schimmelpfennig, 2000; Huffman and Evenson, 2006a; Huffman and Evenson, 2006b; National Research Council, 2002; National Research

[1]Reliable estimates for total private-sector investments in agricultural R&D are not available after 1998.

Figure 1

Real public and private agricultural R&D expenditures in the U.S. since 1970



Source: National Science Foundation; USDA, Current Research Information System (CRIS); ERS.

Council, 2003). Over the last few decades, changes have occurred in constant-dollar funding levels for various other disciplines supported by the Federal Government as shown in figure 2. Biomedical research increased the most; but research in the other life sciences, such as agricultural sciences and biology, as well as engineering, environmental sciences, and computer sciences, increased over most of the period since 1980, except recently between 2003 and 2005.

This report documents changes in funding of public agricultural research between 1980 and 2005—about the time the growth in public expenditures slowed and was surpassed by private expenditures—with the intention of understanding how public research topics have been impacted. Formula and competitive funding changed during that time period, and by delving deeper into which topics are funded by different funding mechanisms, we can analyze the ways in which research topics and output have been affected. Although definitions of basic and applied research are often debated, many policy prescriptions continue to call for greater emphasis on basic research. Thus, we analyze how changes in funding mechanisms have affected the distinction between basic and applied research.

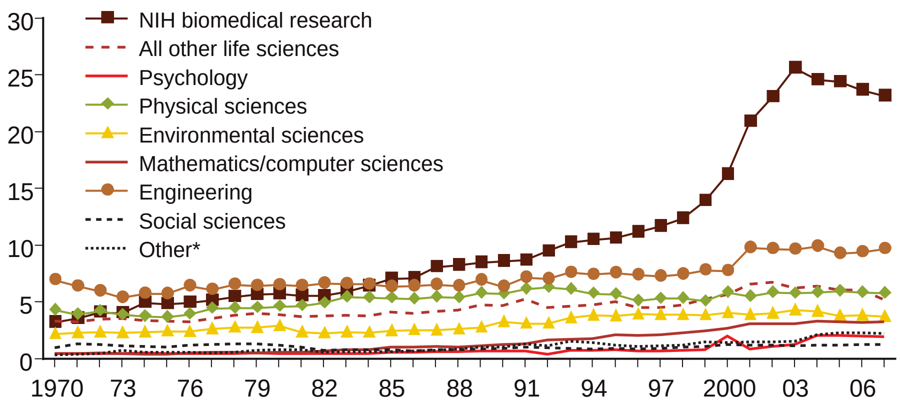
The "Golden Age" of agricultural research that began in the early 1950s was largely the result of an expansion of public support for the sciences following World War II (Bush, 1945; Alston and Pardey, 1996). Public support for agricultural research grew rapidly in real terms, compared with its pre-war growth rate, despite the fact that public agricultural research spending, as a percentage of all public non-Defense research, fell during the 1950s and early 1960s before it stabilized (National Science Foundation).[2]

[2]In the 1950s and 1960s, general science/space/technology dominated the non-Defense research portfolio.

Figure 2

Trends in federal research by discipline, fiscal years 1970-2006

Billion dollars (constant FY 2007 dollars)



Note: Life sciences are split into National Institutes of Health (NIH) support for biomedical research and all other agencies' support for life sciences.

* Other includes research not classified (includes basic research and applied research; excludes development and R&D facilities).

Source: National Science Foundation, *Federal Funds for Research and Development FY 2004, 2005, 2006, 2006.* FY 2005 and 2006 data are preliminary. Constant-dollar conversions are based on Office of Management and Budget's gross domestic product (GDP) deflators.

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Many agricultural research advances during this period originated in the United States and were disseminated around the world through public and private channels, more as a result of “design transfer” or “capacity transfer” than through the direct transfer of materials such as plant varieties (Pardey et al., 2006; Hayami and Ruttan, 1985). The resulting agricultural products improved the health and welfare of many Americans and influenced the “Green Revolution” in many developing countries, particularly in Asia and Latin America.

Changes in Federal investments in agricultural research have been taking place since the 1960s, but became more pronounced after 1980 as private-sector agricultural research expanded. One notable change in public agricultural research funding since 1980 has been increases in real (inflation-adjusted) competitive funds and decreases in real formula funds. Formula funding, or block grants to States, as formula funds are sometimes called, has declined in real terms, while industry agreements and non-USDA Federal agreements have risen. There have also been real increases in competitive and special-grant programs, and these are both often topically oriented. To examine the impacts of these funding changes on the resulting portfolio of public-research results, we first consider overall changes in SAES and intra-mural research individually in some detail.

About the Data

Data for this report have been obtained primarily from the Current Research Information System (CRIS—see following section) maintained by USDA's Cooperative State Research, Education, and Extension Service (CSREES). CRIS is the only data source that compiles information on public agricultural research expenditures from all sources, and it covers public agricultural research expenditures for the longest period of time. The data in CRIS are based on reports by the institutions making the research expenditures, not by the institutions providing the funds. In some cases information from research performers might differ from information from funding sources, but the CRIS data are useful because they are the least fragmentary. Nonetheless, there are some gaps in the CRIS data, notably in certain years for Federal agricultural R&D agencies. Therefore, data for aggregate Federal agricultural R&D expenditures have also been supplemented with information from the National Science Foundation's *Federal Funds for Research and Development* series or obtained from budget personnel at the Federal agencies. Dollar amounts have been converted to real 2000 dollars using a research deflator (see page 6).

The charts in this report are of three basic types (table 1). The first six charts provide background information, and the notes indicate the sources, including CRIS, from which the data are taken, as well as the time period covered. The bulk of the analysis in the report uses two types of CRIS-based data. Time series charts cover the period 1980-2005, and they are constructed with CRIS data for many different types of public agricultural research funding, taken from published reports. They are supplemented where necessary with information from other sources, such as the National Science Foundation and USDA agency budget directors. The other charts compare research topics (e.g., crops, livestock, environment, etc.), research types (e.g., basic, applied, and developmental) for different means (e.g., formula funding, competitive grants, or special grants) by which USDA funds the SAES. These data compare the years 1998 and 2003. They were also obtained from CRIS, but through special queries that allowed disaggregation below the levels found in published data. There are several reasons for the narrower focus. First, even though USDA funding to the SAES has become a smaller part of public agricultural research, it is often viewed as a leading indicator of Federal research policy. Second, definitional changes within the CRIS system, for example concerning "research problem areas" or "knowledge areas" make it harder to ensure strict comparability for years before 1998 or after 2003 (see page 5).

Table 1
Approaches to public agricultural research expenditures used in this report

Type of figure	Uses CRIS data from published reports, with supplementation	Uses CRIS data from specialized queries	Time period	Charts
Background	Yes	No	Varies	1-6
Time series	Yes	No	1980-2005	7, 14, 15
Comparison of means by which USDA funds the SAES	No	Yes	1998, 2003	8-13, 16-19

The Current Research Information System

CRIS is USDA's "documentation and reporting system" for ongoing and recently completed research and education projects in agriculture, food and nutrition, and forestry. Projects are conducted or sponsored by USDA research agencies, State Agricultural Experiment Stations (SAES), the State land-grant university system, other cooperating State institutions, and participants in a number of USDA-administered grant programs. The CRIS system is maintained by USDA's CSREES. Data in the CRIS system are based on information received from the institution performing the research.

CRIS reports public agricultural research expenditures in the United States, regardless of the source of the funds. Industry-sponsored research performed by a SAES would be recorded in CRIS, but agricultural research funded and performed by the private sector would not.

CRIS' predecessor, the Inventory of Agricultural Research, dates back to 1966. Like CRIS, the Inventory of Agricultural Research was maintained by CSREES and its predecessor agency, the Cooperative State Research Service. Printed reports were made available through fiscal year 1997. The CRIS system is now Web-accessible at http://cris.csrees.usda.gov. Summary reports on the Web can be found for FY1993 on.

Standard data breakdowns are by institutional research performers (SAES, USDA agencies, other cooperating institutions) and by funding sources. Different sources of funds for public agricultural research include appropriations by USDA for research performed by USDA agencies; CSREES-administered funds for SAES research; other USDA funds (contracts, grants, and cooperative agreements between SAES and USDA research agencies); other Federal monies, (contracts and grants between SAES and Federal agencies such as the National Institutes of Health (NIH), the National Science Foundation (NSF), and the U.S. Department of Energy (DOE)); State appropriations; and other non-Federal sources, which include both support from private industry for SAES research and income from product sales.

Since the Inventory of Agricultural Research was created, there have been three primary research classification schemes through which the data have been broken down in publicly reported documents:

1. Although definitions have changed over time, classification of research expenditures by "commodity" in earlier reporting periods and by "subject of investigation" in more recent reporting periods refer not only to traditional agricultural commodities such as wheat or beef cattle, but also to technology areas not associated with specific commodities, such as "watersheds," "machinery," or "the farm as an enterprise."

2. Classifications by "problem area," "research problem area," or "knowledge area" (the most recent CRIS term) refer to subjects such as "management of range resources," "plant genetic resources," "animal diseases," and "quality maintenance in storing and marketing of food products." These definitions and categories, too, have changed over time.

3. A third means of disaggregating the CRIS data is by "field of science"—biochemistry, genetics, immunology, engineering, statistics, and so on. It is possible to disaggregate CRIS data in other ways, but in some cases this would need to be done through a special query submitted to CRIS personnel, as the disaggregation would not be reported in standard tables.

Creating a Research Expenditure Deflator

Price deflators correct for the effect of inflation on expenditures. It is difficult to use deflators in relation to research because research has substantial fixed costs that should be allocated across several or more periods. Not even all fixed costs are equal, with expenditures on computer hardware and software or Internet connections having substantially different impacts today than they did 5 or 10 years ago. Laboratory space has a more stable impact on research, but it might take 15 or even 30 years for some research investments to pay off. With these difficulties in mind, the (unpublished) updated research price deflator used in this report was constructed based on Klotz et al. (1995) and Pardey et al. (1989).

Public Agricultural Research as a Federal-State Partnership

The public agricultural research system in the United States comprises a Federal-State partnership. The Federal Government funds intramural agricultural research at three USDA agencies—the Agricultural Research Service (ARS), the Forest Service (FS), and the Economic Research Service (ERS). ARS, the largest of the three, conducts research on crop and livestock production and protection, human nutrition, and the interaction of agriculture and the environment.

FS administers programs for applying sound conservation and utilization practices to natural resources of the national forests and national grasslands. FS also promotes these same practices on all forest lands through cooperation with States and private landowners, and by carrying out forest and range research.

ERS provides economic research and information for public and private decisionmaking on economic and policy issues related to agriculture, food, natural resources, and rural America.

The Federal Government also funds extramural research at State institutions, which include SAES that are housed at land-grant universities, 1890s institutions, forestry schools, and veterinary colleges, as well as other cooperating institutions that are not part of the SAES. Although CSREES-administered funds are a very important component of SAES funding, since 1980 the proportion of SAES expenditures that are CSREES-administered has been less than 20 percent. The State institutions are funded by a combination of Federal, State, and private sources, which will be outlined in further detail below.

This decentralized State-led structure has resulted historically in geographically specific applied research. Federal research funding, on the other hand, is intended in part to promote basic research and to promote interstate research spillovers. There are two reasons for the Federal Government to maintain a strong intramural research program:[3]

1. The effectiveness of the State-led system depends on regional and interregional coordination that is provided by intramural USDA research.
2. There are research problems that are important nationally that may receive minimal attention from SAES or regional research programs and so need to be addressed by intramural USDA programs (Fuglie et al., 1996; Huffman and Evenson, 2006a).

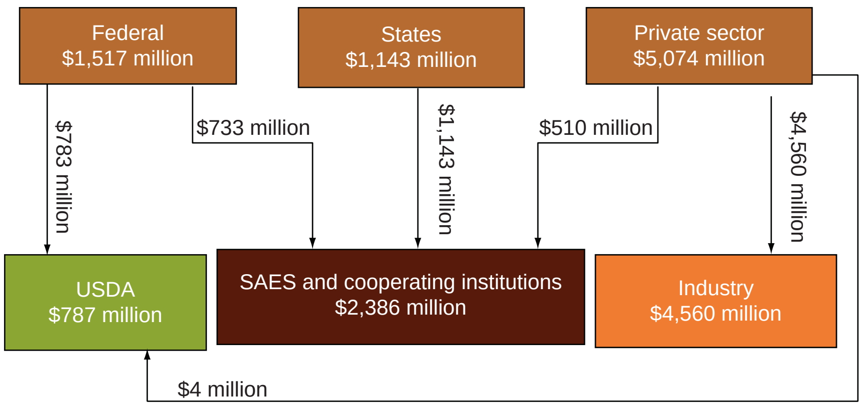
Figure 3 outlines schematically the flow of all research funds, public and private, from sectors that supply resources to the sectors that perform or coordinate the R&D. Indicator data are for 1998, the last year for which estimates of private research expenditures are currently available.

Figure 4 further disaggregates public agricultural research expenditures by funding source for 2005. In this year, USDA intramural research made up 29 percent of the public expenditure total. Combining this amount with USDA funds supplied to the States, USDA funded 43 percent of all public research.

[3]Federal funding of extramural research that *explicitly* addresses Federal research goals can also address these concerns. In particular, CSREES competitive grants can be used to encourage non-Federal researchers to address national problems.

Figure 3

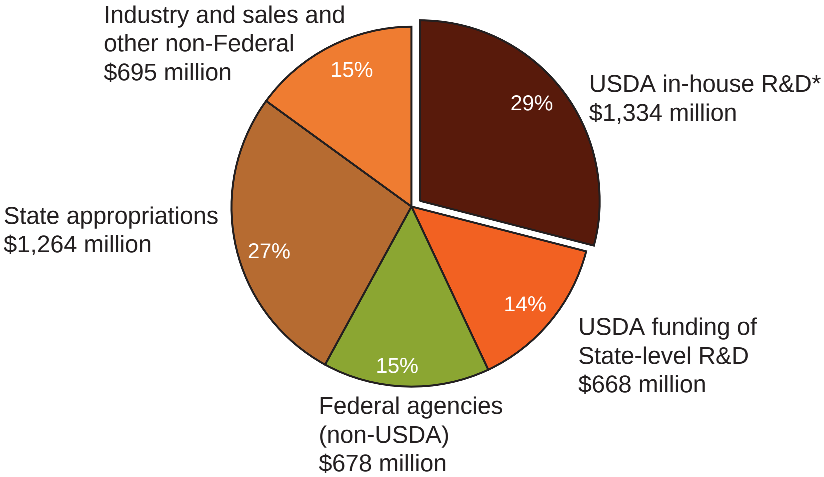
Sources and flows of funding for agricultural research in 1998 (nominal dollars)



Source: USDA, ERS (update of fig. 3, p. 9, AER-735, K. Fuglie et al., 1996) and CRIS.

Figure 4

Distribution of all public agricultural research expenditures (USDA inhouse and State) in 2005, by funding source (nominal dollars)



*Approximately 4 percent of USDA research funding comes from non-USDA sources.

Source: USDA, CRIS.

The SAES and other cooperating State institutions (OCIs) were responsible for over 70 percent of total public agricultural R&D expenditures. The single largest source of these funds was State appropriations, but USDA funds, funds from other Federal agencies, and funds from the private sector all contributed to State-level spending.

Funding of agricultural R&D undertaken at State-level institutions is further disaggregated in figure 5. This figure excludes Federal intramural spending (mostly at ARS), but includes all sources of funding for agricultural R&D at State-sponsored research facilities or other non-Federal institutions (jointly considered State-level research in this report). Note that the percentages for each spending source are based on total public agricultural R&D spending and match those reported in figure 4.

USDA Funding of State Agricultural Experimental Stations Remains Important

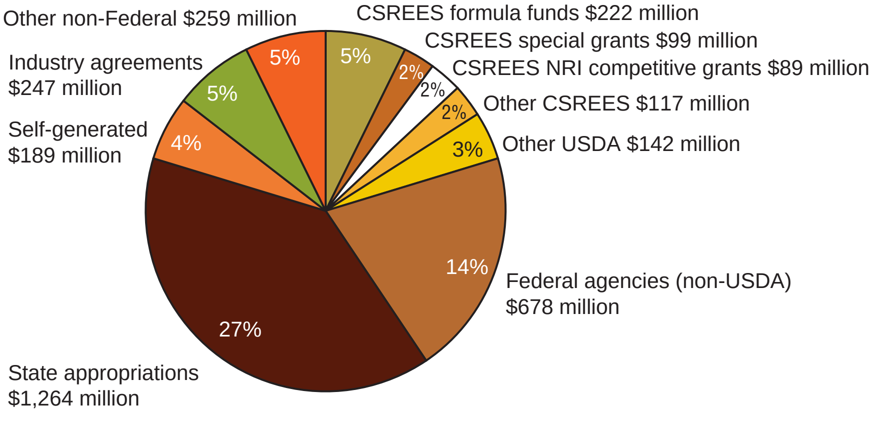
USDA funding of the SAES has been important historically and is still central to today's research policy debates because that funding is considered an indicator of national agricultural science policy (Huffman and Evenson, 2006a). Much of the USDA funding of State-level research is administered by CSREES through formula funds, special grants, or competitive grants, as well as through a variety of other funding options. These three funding sources are discussed in particular detail in this report. In addition, other USDA agencies sponsor State-level research through contracts, grants, and cooperative agreements.

Historically, most USDA extramural research funding to the States has gone to the SAES. In 2005, just under 8 percent of USDA extramural funding went to non-SAES institutions, which can also be identified by the States in which they are located, and so are included in State-level research. The only other funding source contributing notable amounts to agricultural research at non-SAES institutions consisted of Federal agencies other than USDA. In 2005, about 2.5 percent of this non-USDA Federal money did not go to the SAES, but to other cooperating institutions.

Just as with USDA funding, some of the other funding of State-level research can be disaggregated. For example, private support of State-level agricultural research comes through self-generated funds, such as product sales, as well as from industry research agreements and other, unspecified non-Federal sources.

Figure 5

Distribution of all State-level public agricultural R&D expenditures in 2005, by funding source* (nominal dollars)



*Percentages refer to percent of total public agricultural R&D expenditures, Federal level and State level, and so do not sum to 100 percent. USDA inhouse R&D expenditures—accounting for 29 percent of total public expenditures—are not represented in this figure.

Source: USDA, CRIS.

Mission Areas Have Remained the Same, Specific Crop Research Has Changed

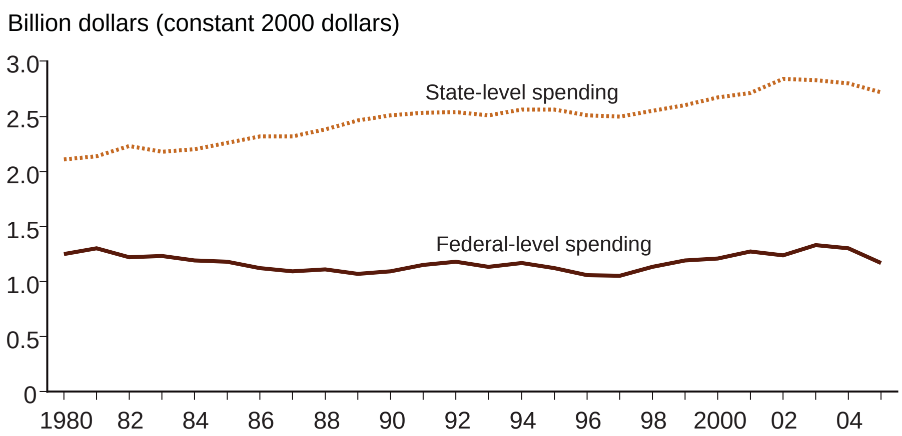
USDA's mission, among others, is to provide public-research leadership in many areas "from human nutrition to new crop technologies that allow us to grow more food and fiber using less water and pesticides" (www.usda.gov). These mission areas have remained the same over recent decades, but the specific commodity focus of research can change depending on the comparative advantages of U.S. and foreign producers, as well as contemporary issues. Public and private research both contribute, but in different ways, with public research more likely to provide advances on topics with limited or at least not immediately apparent marketable potential. The ARS Office of Technology Transfer exists to help move ARS research, most notably from applied and developmental projects, toward private development when the potential exists.

The SAES conduct most public agricultural research. Total real expenditures by the SAES have trended upward since 1980 while real Federal intramural agricultural research expenditures fell slowly until the late 1990s (fig. 6). Between 1997 and 2003, real intramural expenditures bounced back 25 percent before leveling off in 2004, then falling in 2005.[4] Even with the late increase in intramural spending, real spending at the State level was more than 2.3 times higher ($2.72 billion vs. $1.17 billion) than spending by the Federal intramural agencies in 2005. In 1980, the ratio of SAES to intramural research was 1.7 times as much ($2.11 billion vs. $1.25 billion).

The Federal Government is by far the single largest source of public agricultural research funding. From 1997 to 2004, real Federal research money grew by about a third, due in part to increases in the amount of non-USDA Federal funds obtained by the States, the recovery in USDA intramural funding just mentioned, and a slight recovery in total CSREES-administered funds (but not formula funding) in the most recently documented years. Total Federal investment in R&D did decline in 2005, the most recent year for which data are available, but it was still 24 percent greater than the 1997 level in real terms.

Figure 6

Public agricultural research spending, 1980-2005



Source: USDA, CRIS; National Science Foundation, *Federal Funds for Research and Development*.

[4]The decline in real Federal-level expenditures between 2004 and 2005 was caused by a combination of a decline in nominal expenditures and an increase in the R&D deflator.

Funds appropriated by State legislatures declined in real terms in the early 1990s, and declined again after 2000. State appropriations were still the largest source of SAES expenditures, but they fell by 16 percent in constant dollars between 2000 and 2005 and were lower in real terms in 2005 than they were in 1980. Part of the explanation for this could be that part of the State appropriation was a match component to federally provided formula funds that were administered by CSREES (see box, “Formula Funds,” p. 14). Formula funds remain the largest source of USDA agency support for the SAES. Formula funds declined from around $350 million in the early 1980s to $182 million by 2005 (constant 2000 dollars) (fig. 7).

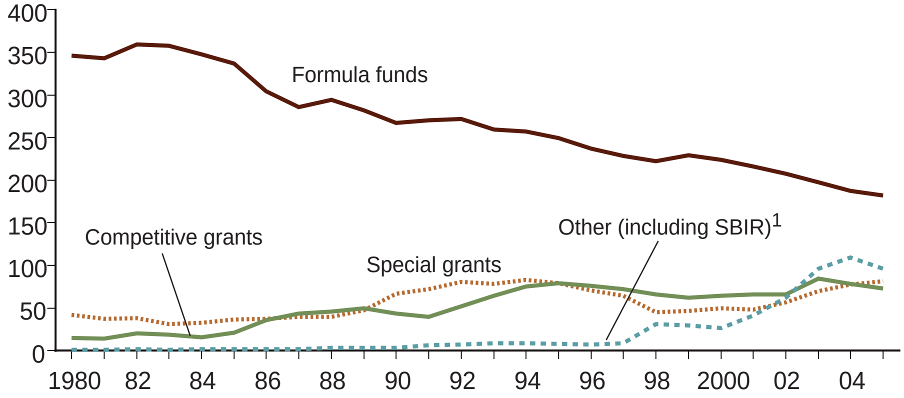
The SAES managed to offset declines in legislative funding through increases from two major sources. Between 1980 and 2005, private contributions to SAES through industry agreements, sales, and other non-Federal sources grew by over 70 percent to a real level of $571 million. The other expanding source of SAES funding was other Federal (non-USDA) funds, which more than tripled between 1980 and 2005. Nearly 60 percent of this increase occurred after 1998. In 2005, real SAES funding from other Federal sources, $557 million, was almost identical to the $571 million received from industry and other non-Federal sources. It is worth noting that each of the SAESs had its own mix of these sources and each had more or less reliance on competitive sources of funding.

Though declining formula funds remained the largest component of CSREES- administered funds at over 40 percent in 2005, all three of the other CSREES funding mechanisms showed real increases after 2000 (fig. 7). Other nonspecified CSREES-administered funds rose the most, but competitive National Research Initiative (NRI) grants, and special grants (which are congressionally awarded funds) also showed increases. Other nonspecified CSREES-administered funds are mainly competitively awarded and include funding for aquaculture centers, integrated activities under Section 406 legislative authority, and other legislative authorities, such as the International Science and Education Grants Program (J.H. Bahn, D.

Figure 7

CSREES-administered funds, 1980-2005

Million dollars (constant 2000 dollars)



[1]SBIR = USDA’s Small Business Innovation Research.
Note: Some categories in fiscal year (FY) 1980 and FY 1981 are estimated from more aggregated data.

Source: USDA, CRIS; ERS agricultural research deflator.

Unglesbee, personal communications, 2007).[5] These funds include the Food and Agriculture Defense Initiative, which may be one reason for the increase in the mid-2000s.

[5]Section 406 is a funding vehicle for programs in the CSREES that integrate research, education, and extension.

USDA's Small Business Innovation Research (SBIR) program, which we have included with the "other" category, is a different, small-scale competitive-grant program that awards grants to American-owned and independently operated for-profit businesses of 500 employees or fewer. There are SBIR programs at 10 other Federal agencies, and these agencies are required to apply 2.5 percent of their extramural research dollars toward small businesses. Since its inception in 1988, the USDA SBIR program has awarded over 1,700 project grants.[6]

[6]Phase I SBIR grants are limited to no more than $80,000, and Phase II SBIR grants to no more than $350,000. USDA's total SBIR funds each year have averaged less than $3 million annually since 1991. Other unspecified CSREES-administered funds, with which they have been grouped here, were also low until 1997, after which they rose.

Recent Institutional Changes and Trends in Funding

The public-policy debate concerning the levels, emphases, and mechanisms of public agricultural research funding provides a context for the data summarized in this report. This debate has long been a feature of the funding process. Many of the arguments influencing the debate over the period covered in this report stem from reports from the National Academy of Sciences (1972) and the Rockefeller Foundation (1982). These reports advocated a shift away from geographically specific applied research toward more basic biological research and an increase in peer-reviewed and competitively funded agricultural research. National Research Council publications in 1994 and 2003 continued to back increases in basic research and in competitive funding.

Pros and cons of various agricultural research funding mechanisms, including competitive grants and formula funds, have been discussed by Alston and Pardey (1996) and Day Rubenstein et al. (2003). Huffman and Evenson (2006b) also discussed the relative merits of these two mechanisms, but, in contrast to the National Academy or the Rockefeller Foundation, they argued that transaction costs severely limit the effectiveness of competitive funding instruments.

Policy proposals have continued to stress competitive funding, fundamental agricultural research, and research aimed at broad national goals. One approach for increasing competitive allocations has been to propose greater emphasis on competitive grants within existing authorizations. However, an important recent change to research policy has been the proposed combination of changed funding mechanisms with institutional reorganization through the creation of a National Institute to fund extramural agricultural research, primarily through competitive grants.

For example, in 2004, the Research, Education, and Economics Task Force at USDA, composed of experts from academia and from USDA, developed a proposal for such an institute. As envisioned, the mission of this institute would be to support fundamental agricultural research with a goal of increasing the international competitiveness of American agriculture. The primary funding mechanism of the proposed institute was to award new competitive peer-reviewed grants that would be *in addition to* existing competitive public research funding.

The Food, Conservation, and Energy Act of 2008 (the 2008 Farm Act) states that the Secretary of Agriculture shall establish a National Institute for Food and Agriculture. As stated by the Act, NIFA will administer research funds and programs formerly administered by CSREES. NIFA will replace CSREES as of October 1, 2009. The Act also authorizes $700 million in competitive grants under the Agriculture and Food Research Initiative, to be administered by NIFA. This, however, is authorized funding; past competitive funding instruments such as the NRI, discussed below, have been authorized at higher levels than have been appropriated for actual spending.

Formula Funds

In addition to competitively awarded funds, a major source of funding for public research provided by USDA's Cooperative State Research, Education, and Extension Service comes from formula funds. These Federal funds provide support for research and extension activities at land-grant institutions and are appropriated to the States on the basis of statutory formulas that have changed only infrequently, as the result of legislation. Eligibility is limited to cooperating institutions, which are mainly 1862, 1890, and 1994 land-grant institutions.

Hatch Act formula funds support the State Agricultural Experiment Stations. SAES are required to provide matching funds at least equal to the federally appropriated Hatch funds for that State. A certain portion of these funds are allocated to a multistate research fund that provides money for cooperative research employing multidisciplinary approaches conducted by the SAES, working with other SAES, the Agricultural Research Service, or a college or university, to solve problems that concern more than one State.

Evans-Allen Program formula funds support 1890 land-grant institutions. Recipients of these funds must also provide a 50-percent match from non-Federal sources. McIntire-Stennis formula funds support State-designated institutions' cooperative forestry research programs.

Animal Health formula funds support research into the prevention and control of animal diseases that affect agricultural productivity. The Smith-Lever Act provides Federal formula funds through the Cooperative Extension Service for cooperative extension activities. The law requires that States provide a 100-percent match from non-Federal sources. Formula funds also support extension activities through Extension Programs for 1890 Institutions, the Renewable Resources Extension Act. Formula funds are also provided for education activities through the Tribal College Endowment Interest Program.

Competitive Grants and Competitive Funding in the CRIS System

Public policy discussion in agricultural research funding has frequently considered what percentage of public-research funding should be committed to basic research, and what percentage should be competitively awarded. One policy response to these ongoing discussions has been to increase competitive grants funding through CSREES. Analysis of competitive grants funding (Day Rubenstein et al., 2003; Huffman and Evenson, 2006b) has focused on CSREES-administered competitive grants. These grants were initiated in 1978, grew somewhat in funding in the mid-1980s, and received an additional boost after 1991 through National Research Initiative (NRI) funding.

It is difficult to identify competitive research funding for agriculture outside of named programs such as the NRI. Both sources and performers of public agricultural research in the United States are numerous. Some aspects of competitive grants (e.g., peer review) are applied in other areas of public research funding. And it is certainly conceivable that more full-fledged competitive processes could be applied at times to funding sources outside the NRI. In the time frame we are considering, expenditures from the CSREES-administered NRI program can be tracked most consistently over a relatively lengthy time period.

However, in addition to the NRI program, CSREES competitively funds research for 20 other initiatives, including aquaculture centers; the International Science and Education Grants Program, which includes the Food and Agriculture Defense Initiative; disadvantaged farmers; 1890s institutions (historically black universities); and small business research under the SBIR program. By far the most likely additional source to be primarily competitive in nature would be funds received by the SAES from non-USDA Federal sources. In many cases, SAES have also received funding from Federal agencies such as the National Institutes of Health, the Department of Energy, the National Science Foundation, and so on, likely obtained through a competitive process. Such funds are not explicitly listed as "competitive" in the CRIS system.

Basic and Applied Research in the CRIS System

Students of science and science policy have often attempted to distinguish between fundamental ("basic") research and applied research. The first definitions below are grounded in the linear model, in which research is conceptualized as flowing from basic or fundamental research to applied research (Bush, 1945). Almost from the time Vannevar Bush formalized this model, the model has been under criticism and revision as an inadequate representation of how scientific progress and practical applications are made. Nonetheless, the distinction between basic and applied research continues to be part of ongoing debates over science policy.

Basic research is sometimes considered to have the primary objective of advancing knowledge and understanding the relationships among variables. It may be thought to be driven by the researcher's curiosity, and conducted without a practical end in mind. It may have unexpected results pointing to practical applications, although they are not the focus of the research. In any case, basic research provides the underpinning for further research, both basic and applied.[7]

Applied research is performed to solve specific, practical questions. Its principal purpose is not to gain knowledge for its own sake. It is often considered to be founded primarily on basic research.[8]

"Development" or "developmental" research refers to activities that are even closer to the production of a marketable product or process. It can be defined as systematic application of knowledge directed toward the production of useful materials, devices, and systems or methods. This can include the design, development, and improvement of prototypes.

The linear model has been subject to a number of criticisms. In fact, most representations of the linear model do not envision a stark distinction between basic and applied research, but rather indicate a continuum flowing from the most basic to the most applied research. Some observers have also noted that there are often feedbacks from applied to basic research. In

[7]The Food, Conservation, and Energy Act of 2008 defines "fundamental" research as research that "(i) increases knowledge or understanding of the fundamental aspects of phenomena and has the potential for broad application; and (ii) has an effect on agriculture, food, nutrition, or the environment." Note that the first part of the definition is similar to our discussion here; the second part actually specifies the sectors of application.

[8]The 2008 Act defines applied research as "research that includes expansion of the findings of fundamental research to uncover practical ways in which new knowledge can be advanced to benefit individuals and society."

attempting to solve certain practical problems, scientists at times have to revisit fundamental scientific questions.

Yet other students of science have argued that there is no strict association between a motivation of fundamental understanding and a motivation based only on curiosity, devoid of considerations of use. Stokes (1997) proposed a quadrant model:

Research is inspired by:

		Considerations of use?	
		No	Yes
Quest for fundamental understanding?	Yes	Pure basic research (Bohr)	Use-inspired basic research (Pasteur)
	No	*	Pure applied research (Edison)

* Research that "systematically explores particular phenomena without having in view either general explanatory objectives or any applied use to which the results will be put."

Source: Based on Stokes, 1997.

At times, a distinction between basic and applied research has been made based on the amount of time between research and reasonably likely practical applications. But once again, the study of any particular research development usually shows that the "paths between scientific discovery and new technology" are "multiple, unevenly paced, and nonlinear" (Stokes, 1997).

Whatever model of basic and applied research is chosen, agricultural research would not be categorized as the most pure basic research. As with many other research areas, for example, biomedical research, almost by definition agricultural research is conducted with considerations of use. Although fundamental biological, chemical, or physical insights are required, application to a particular economic activity, agriculture, is intended. However, as noted in this report, a number of observers have believed for some time that future progress in agricultural science is dependent on a greater emphasis on basic biological understanding.

When measuring basic and applied research, the CRIS database relies on a simple scheme. For each public agricultural research project, respondents to the CRIS questionnaire are asked to indicate the percentage of each project devoted to basic research, the percentage devoted to applied research, and the percentage committed to development effort. (As noted, "development effort" would refer to research that is not only designed to answer a practical question, but is also intended to yield a feasible product or process.) This method is not without problems. For example, different researchers might divide the same research project into basic and applied components in different ways. Researchers might also tend to rank their projects differently depending on whether they thought basic or applied research was more likely to receive funding. We have assumed in this report that researchers have tended to classify their projects consistently over time.

Alternative means of determining which research projects (or components of research projects) are basic, applied, or developmental would add significantly to the cost of data development, however. For example it might be possible to design an index of “basicness” calculated on predetermined criteria, or to make the determination by a single, centralized committee rather than relying on project-by-project respondents.

It is possible to regard the attribution of public agricultural research expenditures in the CRIS system to basic, applied, or developmental research, based on self-reporting, as a proxy variable for the “true” division among these three categories. Trends in the reported amounts of basic, applied, and developmental research are likely correlated with the trends that would be recorded with some more elaborate means of measurement. This is the assumption made in this report.

Shifts to Competitive Awards and the Limited Impact on Basic Agricultural Research

The largest part of the USDA competitive-grants program is the NRI, which is administered by CSREES. The highest funding priorities for this program are (1) fundamental and mission-linked research, and (2) integrated research, education, and extension proposals that address national and regional agriculture and forestry issues (http://www.csrees.usda.gov/fo/fundview.cfm?fonum=1112). Figure 7 shows that expenditures from NRI, as reported by funded institutions, leveled off in real terms at less than $100 million after the mid-1990s. Particularly in the last years covered by Figure 7, USDA budget summaries record considerably larger amounts allocated under NRI than were reported by recipients to the CRIS system. For example, in 2006, the USDA budget summary indicated nominal NRI outlays of $181 million, or $145 million in real (2000) dollars.

There are over 20 other CSREES-administered competitive-grants programs that focus on sustainable and organic agriculture, socially disadvantaged producers, the 1890 institutions, and other initiatives. Some of the other sources of public agricultural research funding, in particular, money from non-USDA Federal sources, may be competitively awarded, but the NRI and other competitive programs have been the main source of competitive-grant funding aimed specifically at agriculture (see previous chapter section, "Competitive Grants and Competitive Funding in the CRIS System").

Using the CRIS database maintained by CSREES, in this section we examine in detail individual research topics addressed and determine whether the research was more basic or applied in nature, for formula funding, competitive funding, and special grants (see previous chapter section, "Basic and Applied Research in the CRIS System"). Research-topic areas are aggregates of "knowledge areas" previously defined as "research problem areas" in the CRIS Manual of Classification.[9] Comparisons are made between 1998 and 2003 because the CRIS classification system changed between 1997 and 1998, and changed again between 2004 and 2005. Although there is overlap and it is possible to "crosswalk" some data between older research problem areas and newer knowledge areas, a comparison between 1998 and 2003 is more defensible than a comparison over a longer period of time.[10]

These data show that for both basic and applied formula-funded research, plant and animal systems (broadly defined as commodities research) receive the most funding. As can be seen in figures 8 and 9, natural resource and environmental topics are not far behind, but constant-dollar funding for all three topics declined between 1998 and 2003.[11]

Data on NRI competitive funding for basic and applied topics (also reported to CRIS) show that the same three topics are emphasized, with some differences.[12] As can be seen in figure 10, between 1998 and 2003 competitive funding for basic nutrition and food safety research more than doubled, while figure 11 shows that, for applied competitively awarded nutrition/food safety research, the increase was even more dramatic. The overall increase in

[9]If research topic areas are aggregated for formula funds and aggregated over basic, applied, and developmental research, the total equals the formula-funds total. This also applies to other funding mechanisms such as competitive grants.

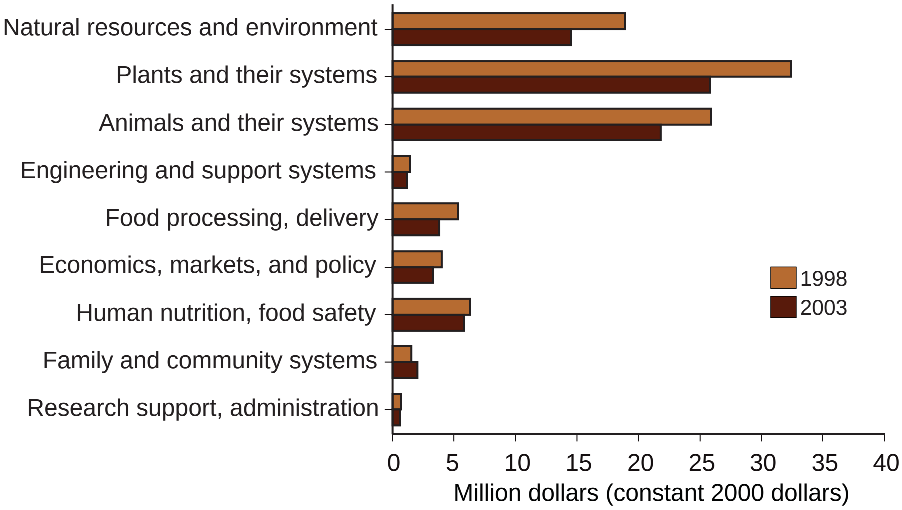
[10]A "crosswalk" table is a table that indicates a rough relationship between old categories and new categories. The relationship is not exact, however, because there is not a one-to-one relationship; furthermore, new categories may be added or old categories dropped entirely.

[11]These allocations of formula funds to topic areas reflect, in part, SAES priorities. However, formula funds comprise four separate legislative instruments, and in some cases are directed to specific research areas such as forestry or animal diseases.

[12]CSREES has potentially more influence over the research areas funded by NRI competitive funding than it does over the areas funded by formula, through CSREES's choice of NRI topic areas and its selection of review panels. CSREES National Program Leaders seek stakeholder input on Requests for Proposals in all competitive funding programs and also review and approve each submitted proposal for formula-funding (J.H. Bahn, personal communication). However, the SAES and other cooperating institutions also play a role, as they choose the areas for which they write research proposals.

Figure 8

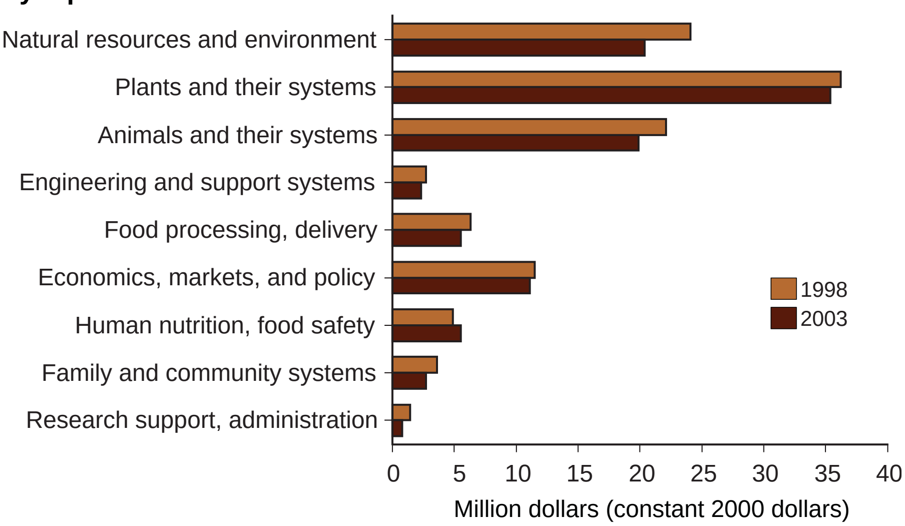
CSREES-administered basic formula funds spent by SAES by topic area



Source: USDA, CRIS.

Figure 9

CSREES-administered applied formula funds spent by SAES, by topic area

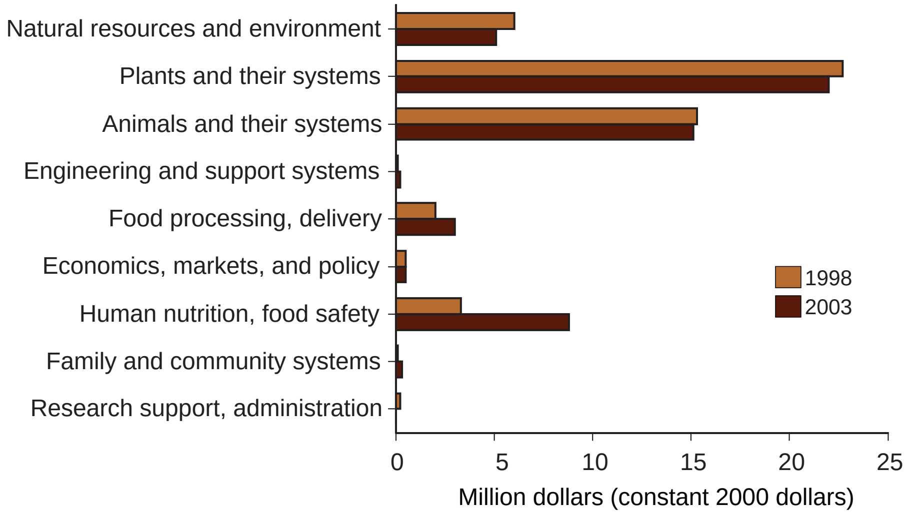


Source: USDA, CRIS.

competitive awards (especially in 2002-03) shows up here as well, with plant and animal systems and environmental topics showing increases between 1998 and 2003. However, in these generally better-funded topics, real funding for competitively financed basic research declined slightly over this period, while real funding for applied research increased. Day Rubenstein et al. (2003) argued that, up to 1997, research funded by CSREES competitive grants was more basic than research funded through other CSREES instruments. These more recent data provide evidence that suggests that in this later period there may have been a partial shift from basic to applied research in competitive grant funding. An example of this shift can be found in the 2003 startup of the NRI-integrated Research, Education, and Extension Program.

Figure 10

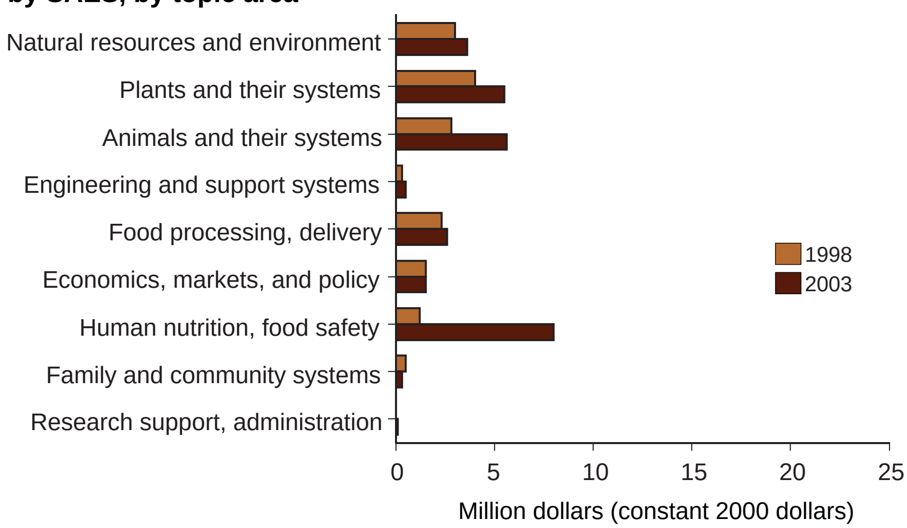
CSREES-administered basic competitive grants spent by SAES, by topic area



Source: USDA, CRIS.

Figure 11

CSREES-administered applied competitive grants spent by SAES, by topic area



Source: USDA, CRIS.

As we have noted, the largest component of the SAES portfolio (State appropriations) has declined in real terms since 1990. USDA funding through CSREES-administered formula funds has fallen at least since 1983. Declines in formula allocations have been somewhat offset by increases in competitive funding and congressional special-research projects. There does appear to have been some shift from basic to applied research approaches, but this distinction may or may not be linked to funding mechanisms. This is notable as competitive funding was originally intended to support more basic research or "the development of fundamental scientific knowledge important to agriculture" (NRC, 1994, p.13). The evidence through 2005 does not support the hypothesis that a shift toward more competitive-grant funding for agriculture has led to greater emphasis on basic research.

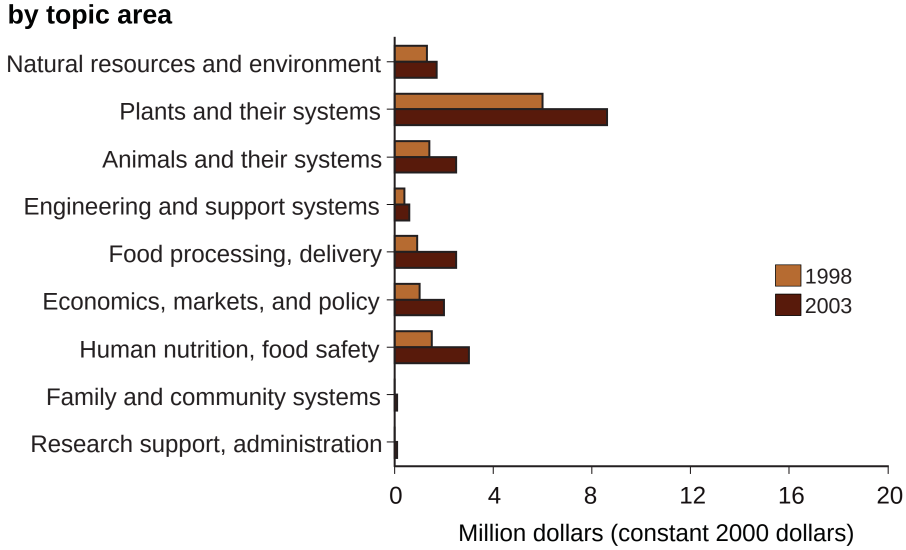
Agricultural biotechnology is sometimes described as a type of basic agricultural research (Traxler, 1999). Whether measured by issued patents, field trials of genetically engineered crops, or adoption of such crops, investment and product development in agricultural biotechnology has accelerated more rapidly in recent years than other areas of agricultural research have (Fernandez-Cornejo and Caswell, 2006; Heisey et al., 2005). But even here, the complexity of defining basic research and the empirical record do not support a clear picture. Pelletier (2006) examined the same CRIS database discussed previously and determined that 3,041 biotech projects were awarded on plants between 1994 and 2002. The main finding of the study is that "transgenic research has overwhelmingly emphasized technology application over basic … research." Several of these factors may be reinforcing an overall movement toward applied public research, and this trend will be re-examined later along with consideration of recent changes in developmental research funding.

The Focus of Special Grants

Special grants are congressionally earmarked funds that are awarded for both basic and applied agricultural research topics. CRIS data are available on topics addressed by this source of funding. There were increases in special grants between 1998 and 2003 in all topic areas except for applied economics research. For both basic and applied special grants, the largest increases were in plants and their systems—research spending on applied plant systems increased by over a third in real terms. Special-grants funding of basic research in food processing, economics, and nutrition also increased. These increases mirrored, to some extent, decreases in formula-funded basic research on plants, food processing, economics, and nutrition. Thus,

Figure 12

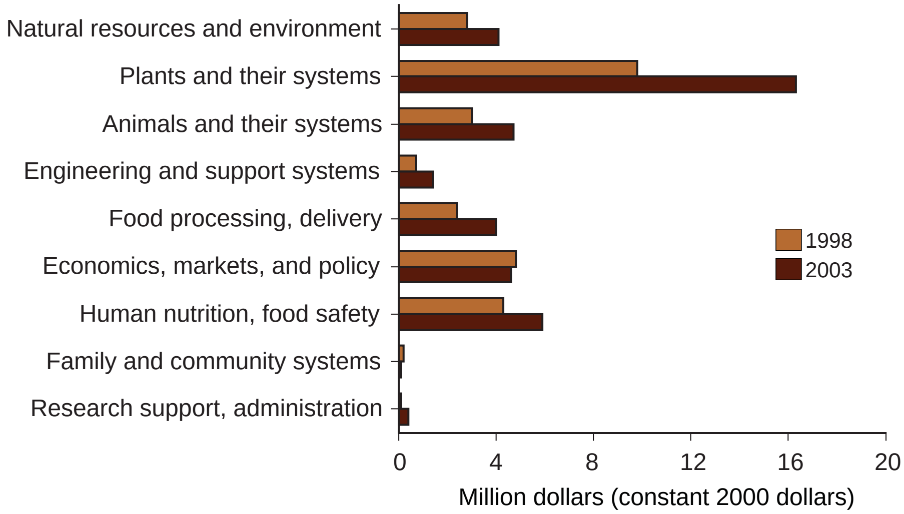
CSREES-administered basic special grants spent by SAES, by topic area



Source: USDA, CRIS.

Figure 13

CSREES-administered applied special grants spent by SAES, by topic area



Source: USDA, CRIS.

increases in special grants as well as in competitive grants have somewhat offset decreases in formula funding for basic research in these topic areas.

Scientific Personnel in ARS and the SAES

The largest intramural portion of the agricultural research budget is allocated to USDA's Agricultural Research Service. ARS and Forest Service received increases in real funding in the early years of the present decade (fig. 14).

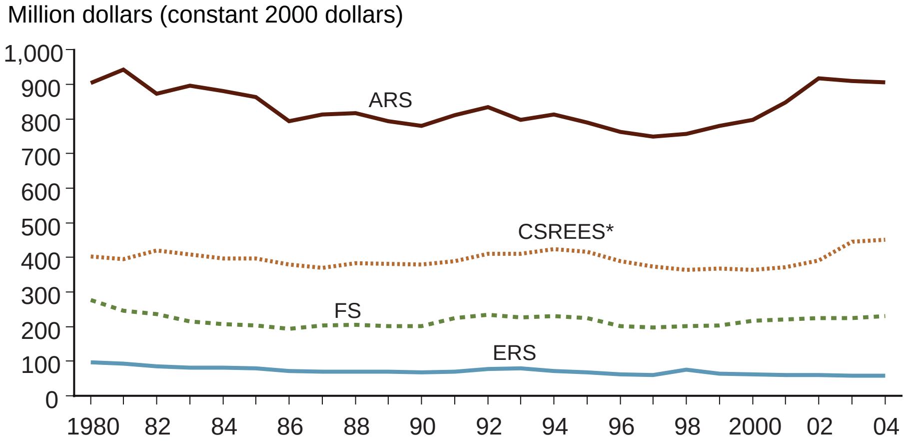
These monetary increases are reflected in increases in scientist years. Scientist years (SYs) are calculated as staffing equivalent to the indicated number of scientists working full-time for 1 year. This trend reversed a general decline in USDA scientist years from 1980 to 2000 (fig. 15), and is in contrast to non-USDA (mainly SAES) scientist years that remained unchanged over most of the same period.

Despite decreases in real formula funding between 1980 and 2005, the SAES maintained stable numbers of scientists. The increase in Federal non-USDA funding suggests that the SAES sought out alternative funding from departments such as Energy, Defense, and Health and Human Services. Increases in revenue from industry agreements, as well as product sales, indicate State scientists were successful in their appeals to private companies. At the same time, SAES appear to have been less successful in getting funding increases from their State legislatures. From 1990 to 2005, Federal formula funds going to the States declined by about $85 million (real 2000 dollars), while State appropriations for agricultural R&D fell by nearly $285 million (real dollars). In other words, State-appropriated money fell by a greater amount than could be explained solely by a fall in matching funds.

That drop in State-appropriated money raises the question of how much influence these other Federal departments and private companies now have on the priorities of SAES research. Foltz and Barham (2006) found that

Figure 14

USDA agencies' research funding, 1980-2004



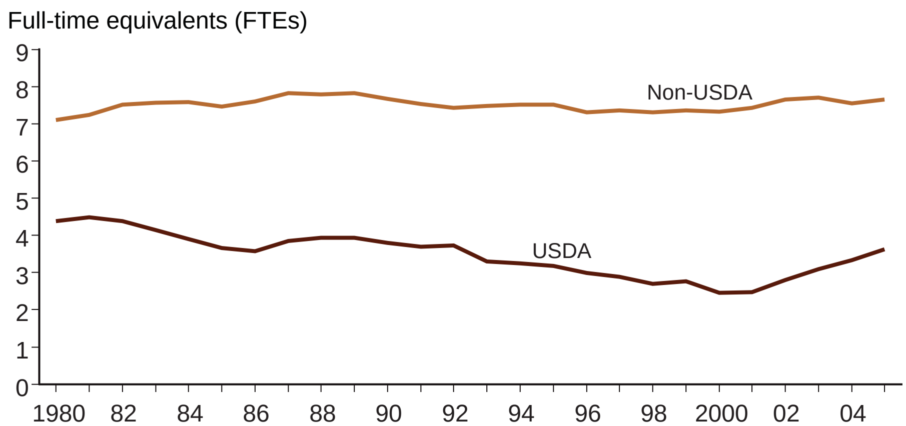
*CSREES research funds are funds used to support SAES research.

ARS = Agricultural Research Service; CSREES = Cooperative State Research, Education, and Extension Service; ERS = Economic Research Service; FS = Forest Service.

Source: USDA, CRIS, and agency budget directors.

Figure 15

Research scientist years at USDA and State-level institutions



Source: USDA, CRIS.

scientists concentrating in agricultural biotechnology tended to receive more National Science Foundation (NSF) and National Institutes of Health (NIH) funding than SAES scientists in other research areas, whereas scientists researching topics other than biotechnology received more funding from industry sources. This suggests nontraditional sources of SAES funding may have different effects on SAES research portfolios or that hiring decisions could influence the composition of the overall research portfolio as new scientists pursue funding from preferred sources. The next section considers how changes in SAES and intramural research might have interacted to influence the overall portfolio of public research since 1980.

Changes in Funding Sources Interact To Influence Research Portfolios

SAES were able to maintain stable staffing levels from 1980 to 2005 because declines in formula funds were accompanied by increases in competitive and special grants, industry agreements, and other Federal funding. As figure 14 shows, ARS is the largest intramural research agency. By agency history and design, the topics addressed by ARS are often similar to those addressed bys the SAES. ARS's National Programs (including 1,200 research projects) are grouped by ARS into topics similar to SAES topics reported to CRIS/CSREES. These ARS research program areas are crop production and protection, animal production and protection, natural resources, and nutrition/food safety (www.ars.usda.gov/research/programs.htm).

Given the size of the SAES research programs, it is not possible to outline fluctuations in funding of individual research programs. Changes in basic and applied research approaches at ARS might have impacts on the research agenda of the SAES, but ARS has maintained a basic-research portfolio of just over 50 percent across all programs for most years from 1980 through 2005. Basic research at ARS accounted for 53 to 54 percent of the total portfolio from 1980 to 2000. From 2001 to 2003, the percent in basic research rose to 55 percent, and for 2004 to 2006 it dropped back to 49 percent (ARS budget office, personal communication, January 2007).

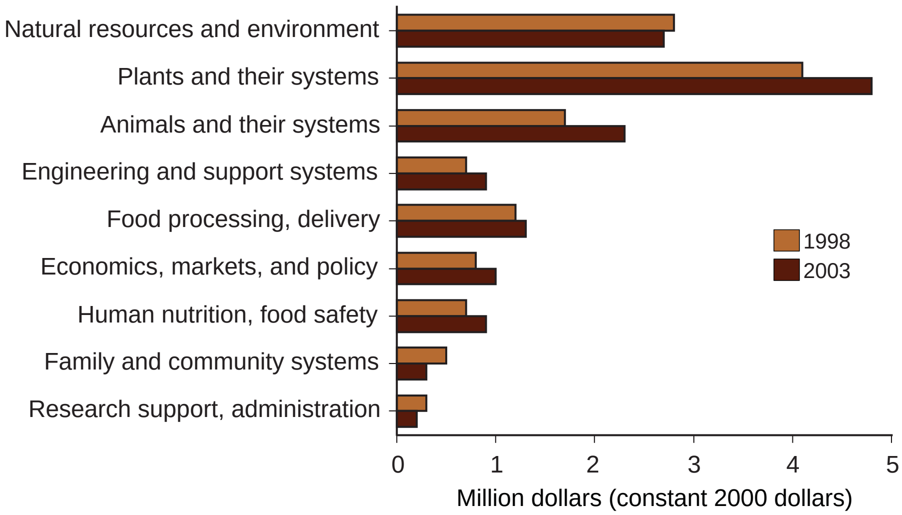
ARS's allocation to developmental research, which is for research on technologies that are closer to market than applied research usually is, remained stable at between 9 to 10 percent throughout the period. Applied research also remained relatively constant at between 35 and 40 percent. Thus, the funding ratios for basic, applied, and developmental research at ARS have held fairly constant. As a result, the shift from basic to applied research within the SAES, whether linked to funding mechanisms or not (which as indicated earlier is difficult to establish), was not offset by a shift in the opposite direction at ARS. Furthermore, an increase in near-market developmental research appeared to reinforce the trend toward more applied research at the SAES, as discussed in the next section.

Growth in Near-Market Developmental Research

Strongly motivated to search for relevance in pursuit of funding options, SAES researchers and administrators have often searched for marketable applications for their agricultural research outputs. To track changes in developmental funding we look at changes in funding from three sources: CSREES-administered competitive grants, formula funds, and special grants. While developmental competitive grants were almost nonexistent in 1998, the topic "plants" was awarded over $500,000 (constant 2000 dollars) competitively for developmental research in 2003. The second-largest competitive developmental topic was nutrition, at over $300,000. Within developmental formula funds, two out of three of the largest topics, plants and animals, rose from 1998 to 2003, while natural resources fell slightly. While there was growth in applied research overall and also growth in basic and applied special grants, special grants for developmental topics fell in all areas except nutrition and research support. The largest percentage decrease was in developmental plant systems research. The overall impact of changes in developmental funding was that the growth in applied SAES research was reinforced by shifts in developmental funding for the SAES (see figs. 16, 17, and 18). Note: the scale for figs. 16-18 is from 0 to $5 million, changed from the scale for figs. 8 to 9 (0 to $40 million), figs. 10 to 11 (0 to $25 million), and figs. 12 to 13 (0 to $20 million).

Figure 16

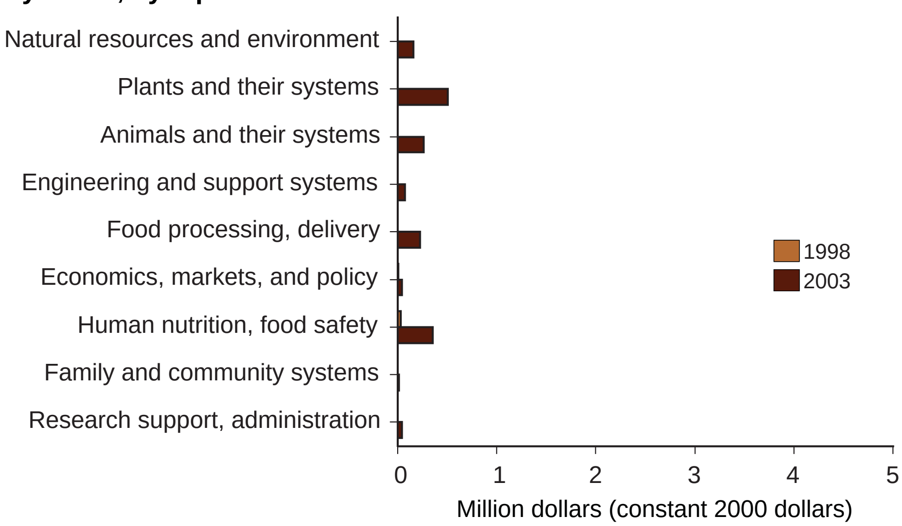
CSREES-administered developmental formula funds spent by SAES, by topic area



Source: USDA, CRIS.

Figure 17

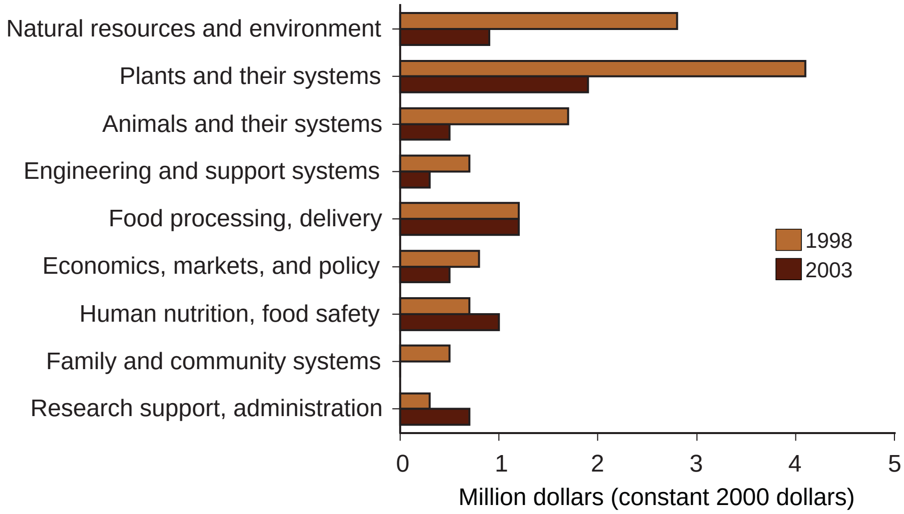
CSREES-administered developmental competitive grants spent by SAES, by topic area



Source: USDA, CRIS.

Figure 18

CSREES-administered developmental special grants spent by SAES, by topic area



Source: USDA, CRIS.

Research Results May Have Additional Impact Through "Spillover"

The U.S. public agricultural research system is a dynamic and fluid environment based on the creation and dissemination of agriculturally related knowledge. One factor that is difficult to control or measure, but has been attempted to be harnessed in some situations, is the tendency of new research results to "spill over"—that is, have an impact outside of the scientific area, institutional affiliation, or geographic region originally targeted, and not always through formal channels. Phone conversations and e-mail exchanges among colleagues and extension agents can disseminate research results before conference paper presentations, submissions to professional journals, or release of public research documents. Once published, research results can find applications in unexpected places, particularly in the age of ubiquitous information technologies, as researchers often scour the Internet for useful information. The importance of this phenomenon for the analysis in this report is that public research influences and is influenced by at least three forms of knowledge spillover:

1. between topics and types of research funded,
2. to and from the private sector, and
3. within and between geographic regions.

The previous section considers some of the difficulties of measuring funding levels for basic and applied research. The corollary to these difficulties is that the impacts of basic and applied research are even harder to measure, especially when spillovers are considered. Taking the definitions and considerations in the previous section as a starting point, more basic research is generally considered to produce more fundamental scientific breakthroughs. Those breakthroughs in turn have the potential to spill over into a greater number of applications, that then could have a greater impact on agricultural productivity growth. This could include overlap from basic biological research that is not funded via traditional agricultural research sources. On the other hand, more geographically focused adaptive research tends to fall into the applied-research category and is generally considered to have less spillover potential. The implication is that one purpose of some competitive-grant programs (e.g., the National Research Initiative and the Initiative for Future Agricultural and Food Systems (IFAFS), run by USDA's CSREES) has been to increase somewhat more basic research and the potential for spillovers on environmental problems, food safety, and nutrition research problems.

Research from other funding sources such as the private sector, however, may include knowledge spillovers in more applied areas. ARS's Office of Technology Transfer is devoted largely to moving USDA-developed agricultural technologies into private-sector markets. Examples of successful OTT projects include poultry vaccinations, low phytic-acid grains that reduce phosphate runoff from livestock operations, and the anti-cancer drug Taxol (National Research Council, 2003). Spillovers also come from private-sector funding and Federal funding sources other than USDA when they make grant awards and thereby help set the public agricultural research agenda. Industry sources, self-generated funds, and miscellaneous non-Federal funds grew between 1980 and 2005 by around 70 percent, reaching $695 million in 2005. These non-Federal sources have their own agendas and accumulated knowledge that they no doubt bring to bear in setting new research priorities, but in the process of establishing common research interests or expertise, these sources may tend to emphasize more applied research.

The U.S. Departments of Defense, Energy, and Health and Human Services have all been increasing their funding of USDA research as well .In June 2007, the Office of Biological and Environmental Research in the U.S. Department of Energy's Office of Science and USDA's National Research Initiative jointly selected 11 projects for awards totaling $8.3 million for biobased-fuel research, working together to promote cross-fertilization of ideas and expertise. "These awards continue a commitment begun in 2006 to conduct fundamental research in biomass genomics that will establish a scientific foundation to facilitate and accelerate the use of woody plant tissue for bioenergy and biofuel" (http://genomicsgtl.energy.gov/research/DOEUSDA/index.shtml).

The final type of spillovers considered, between geographic regions, can be influenced by the first two types of spillovers because private companies can have offices in several regions and the SAESs are actually located in most States. Because the SAESs tend to do more applied research, their results may have fewer opportunities for spillovers. Groups such as the commodity, seed, and chemical industry organizations have had an impact on public spending on activities such as research (Esteban and Ray). Those organizations' interest in specific research may increase regionally specific research and reduce spillovers because major commodities tend to be grown in individual regions and funding for commodity spending also tends to be region-specific. This regional focus would be an example of the more applied nature of some of the agricultural research associated with private firms.

Conclusion

Our review of intra- and extramural public agricultural research, and the interaction of trends in public funding, leads to several conclusions. Policy recommendations from the National Academy of Sciences and the National Research Council (see chapter, "Recent Institutional Changes and Trends in Funding," p.13) in general argued for increasing fundamental research and associated increasing competitive grants funding with the proposed shift of the public portfolio toward more basic research. Despite these policy positions, applied research appears to have received increased attention in the public agricultural research portfolio. Since developmental funding also grew over this period, the increased emphasis on applied public research meant decreased emphasis on basic public research.

Aggregating the data presented in figures 8-13 and 16-18 demonstrates that, as proposals for increasing competitive grants funding have suggested, a higher proportion of competitive grants funding in the mid-2000s was directed to basic research than was the case for either formula funding or special grants. Nonetheless, the percentage of competitive grants funding allocated to basic research fell from 76 percent to 65 percent between 1998 and 2003. The percentage of formula funding devoted to basic research was about 40 percent over that period. The special-grant basic-research percentage was about 30 percent. Combined with the overall shift in the CSREES-administered portfolio from formula funding to competitive grants and special grants, the combined percentage of basic research in this portfolio stayed under 50 percent (fig. 19). This aggregate reduction in the proportion of basic research was reflected in an aggregate reduction in the basic research proportion for the majority of the topic areas, including the topics with the largest budgets—plant sciences, animal sciences, natural resources and the environment, and human nutrition and food safety.

At the same time, as traditional USDA and State sources of research funding to the SAES diminished, the SAES maintained or even increased real funding by tapping both industry and non-USDA Federal sources. These changes may have had an impact on the total public agricultural research balance between basic and applied research, although this is not directly observable in the data used here. The evidence presented above suggests that private funding tends to be directed more toward applied research, and other Federal funding toward basic research.

As we have noted, the decentralized State-led structure of the system has tended to promote geographically specific applied research. The proponents of Federal intramural research funding usually stress basic research, research of national interest, a coordinating role for Federal agricultural research in general, and the encouragement of interstate research spillovers. Thus Federal research could be viewed as complementary to the applied research that individual State institutions and the private sector were likely to pursue. However, we found no evidence to suggest that Federal intramural agricultural research has become more basic to balance out some of the apparent shifts toward applied research at the State level.

Public policy advice has continued to stress the themes of increasing the proportion of basic public research and the use of competitive funding mechanisms. Despite these prescriptions, we found little evidence for actual increases in the percentages of public research expenditures devoted to basic agricultural research. Several propositions suggest that achieving the optimal amount of basic agricultural research and optimal use of competitive funding mechanisms will be more likely if the nature and history of agricultural research are taken into account:

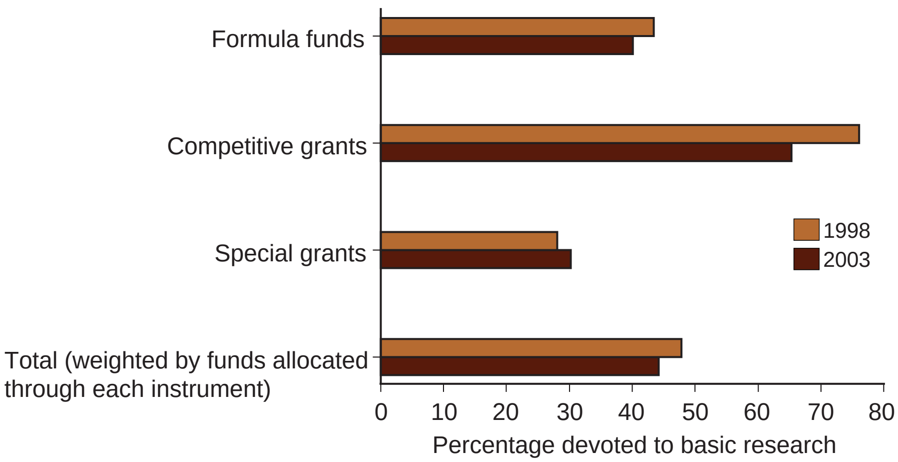
1. Despite agreement on the importance of basic agricultural research and the advances in science applicable to agriculture, State legislatures might be more likely to appropriate funds to research that they believe will benefit their State. To the extent that the same problems are shown to have national significance, as is more commonly the case, then the chances for State funding only go up. As a result, changes in funding mechanisms or institutional design may meet with greater success if they recognize local aspects of research and demonstrate how more centralized or more basic research might lead to research solutions at the local level.

2. Although the history of other major Federal research investments, particularly at NIH, implies that competitive funding can be associated with more basic research, recent history suggests that this effect in agricultural research is more modest and can change over time. Thus, proposals for competitive funding as a tool to promote basic research might be more likely to meet their goals if additional mechanisms—such as explicit guidelines for the nature of peer review and for focus on issues of basic science—are added to the competitive design.

Changes in funding emphasis described in this report indicate that many successful agricultural scientists must be able to adapt their subject areas and research approaches to respond to new funding opportunities. The situation in public agricultural research in recent years has been one in which funding for basic agricultural science from competitive initiatives might have

Figure 19

Percentage of funds devoted to basic research by three CSREES funding instruments



Source: USDA, CRIS.

appeared to represent the most likely opportunities for additional research support. The reality, as we have shown in this report, was that other sources of funding from both Federal non-USDA departments and private companies were at least as important as USDA competitive initiatives. The overall impact of these external forces on the importance given to specific topics in the public agricultural research agenda is still unfolding. One question raised by the findings in this report must be whether this mix of funding sources is the one preferred in terms of the entire picture of public agricultural research support. Making this question even more difficult to answer is the fact that the pace and direction of basic and applied agricultural research itself is a function of technological developments that are evolving rapidly.

We have tried to delineate the trends leading to this situation. As new competitive avenues for public research are considered, and as new organizational structures are implemented, continued attention will need to be given to the preferred allocation of research funds among basic and applied topics and to the funding mechanisms that might be used to reach that allocation. This report is meant to help inform that effort.

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