# Overview and Policy Implications 1

The past decade has brought substantial new pressures to bear on U.S. agricultural research. As science has opened the door to heretofore inconceivable advances, the agricultural research community has broadened its scope from devising new farm production technology to the full realm of agricultural activity—from the time the raw product leaves the farm to the final product in the consumer's home. Further, U.S. society has demanded that the research system expand its focus from increasing agricultural productivity, profitability, and competitiveness to addressing the impacts of agricultural production on the external environment. Of greatest concern have been problems such as water and air quality, nutritional quality, food safety, waste from food production activities, and the economic and social vitality of rural communities. The combination of these pressures has led to considerable change, and demands for continuing change, in agricultural research.

Clearly, more and better research is needed to address these issues adequately. A crucial determination is where and by whom that research should be done. By nature, the public and private sectors conduct very different types of research. Research that creates easily transferable information is more likely to be conducted by the public sector; research that creates information that is proprietary or embedded in a product is more likely to be conducted by the private sector. For example, the public sector develops pure lines and self-pollinated crop varieties that can be used by any seed company, while the private sector develops hybrid varieties proprietary to private firms that must be purchased annually by farmers if they are to be productive. Further, and perhaps more important, if the private sector determines that some research benefits (or costs) accrue to people other than those who use the results, it cannot capture the full returns on its investment, and most likely will not invest sufficiently in such research. The public sector must fill the gap.

Given the ever-greater demands on public agricultural research, however, filling the gap has become increasingly difficult. Very simply, the demand for such research has exceeded the supply available. An effective national strategy, and advances in science and technology of a scale and scope the system has not previously experienced, will be essential in the coming years.

In 1990, Congress became increasingly aware of the changing environment in which agricul-

tural research would be conducted and the need for the focus and scope of agricultural research to change. Accordingly, Congress revised the research title of the Food, Agriculture, Conservation and Trade Act of 1990 (FACTA). Specifically, Congress added major sections to the research title of FACTA on 1) purposes of agricultural research and extension, 2) a national competitive research initiative, 3) sustainable agricultural research, and 4) new crops, products, and uses research.

This study focuses on how the U.S. Department of Agriculture (USDA) has implemented the four new sections of the research title. This chapter includes a brief overview of the U.S. agricultural research and extension system, plus a summary of findings and policy implications for the above four components of the research title. In addition, potential changes in the financing, organizing, and managing of agricultural research are considered. Subsequent chapters treat these topics in greater detail.

## U.S. AGRICULTURAL RESEARCH AND EXTENSION SYSTEM

The U.S. public sector agricultural research system, a dual federal/state system, came into being in the 1860s. It was not until the late 19th century, however, that the system began to provide the scientific knowledge needed to deal with the problems of agricultural development. Today, the federal agricultural research system includes the USDA's Agricultural Research Service (ARS), Economic Research Service (ERS), and Forest Service (FS); and the partner State Agricultural Experiment Stations (SAES) located within the Land Grant University System.

ARS, established in 1953, is USDA's largest intramural research agency. It has major responsibilities for conducting basic and applied research in natural resources, plant science, animal science, commodity conversion and delivery, human nutrition, and integration of systems. ARS employs approximately 2,670 scientists and engineers (of which about 2,500 have doctoral degrees) and had a FY 1994 research budget of $679.2 million. Research is conducted at approximately 100 domestic and seven foreign locations. Five major regional research centers are located in Maryland, Pennsylvania, Illinois, Louisiana, and California. ARS has cooperative research agreements with other USDA agencies, and many of the ARS facilities are located at or near academic institutions. Some ARS staff hold adjunct faculty appointments and participate in graduate teaching (30).

ERS was established in 1961 to provide economic and other social science information and analysis for improving the performance of agriculture and enhancing the economic and social vitality of rural America. ERS collects and maintains a number of historical data series on farm type, size, and number; production and input levels; trade; effects of farm policy; and socioeconomic characteristics of rural areas of the United States. ERS also performs statistical and analytical research, and is organized into four divisions covering commercial agriculture, food and consumer economics, natural resources and environment, and rural economy. ERS has limited funds to contract for research in the academic sector but is not authorized to administer a competitive grants program. The ERS budget for FY 1994 was $55.2 million (30).

The FS is responsible for research on the nation's forests and for technologies useful in the manufacture of pulp and wood-based products. Research topics cover a broad range. The FS also manages 182 million acres of forest. Its research budget for FY 1994 was $193.1 million. Much of the research is conducted through its intramural program and the federal forest experiment stations (30).

The Land Grant University System was established in 1862 by the Morrill Act. There was a need to provide higher education to the masses, with particular emphasis on the children of farmers and industrial workers. The Morrill Act made grants of land to states that were willing to create universities to fulfill this mission. Originally, education focused on agriculture and the mechanical arts, but the focus has expanded to include all of the major disciplinary fields.

The partnership between the state and federal government was extended to agricultural research with the Hatch Act of 1887, which provided federal funding for the support of agricultural experiment stations at land grant universities. Agricultural science had previously been the domain of innovative farmers, inventors, and the industrial sector, and progress had come primarily in the form of mechanical technology. Few states had provided significant funding for agricultural research. Eventually, however, agricultural output did not keep up with demand and food prices began to rise, leading to the passage of the Hatch Act. Nonetheless, it was not until the 1920s that the land grant system was fully functional. Today, there are 57 SAES located in each of the 50 states, the District of Columbia, the Pacific Territories (American Samoa, Guam, Micronesia, and the Northern Mariana Islands), the U.S. Virgin Islands, and Puerto Rico. Six historically black universities (the 1890 universities) and the Tuskegee Institute also conduct publicly supported agricultural research.

The Hatch Act provides research funding to states based on a formula that considers the importance of the agricultural sector to the state's economy. The formula funding system provides stable funding for research programs that may have long gestation periods. All formula funds must be matched by the state. The current formula for funding designates 1955 as the base year and the minimum amount to be allocated.

The federal share of Hatch and related funds (like the special grants described below) was $317.5 million for FY 1993, compared with $331 million in other federal funds (such as USDA's competitive grants program and other federal agency funds) and $1376.3 million of state ($985.4 million), industry and sales ($256.1 million) funds (30).

The structure of the current system was completed with the passage of the Smith-Lever Act in 1914, creating the Cooperative Extension Service (CES), which directly provides farmers with useful information gleaned from the research system. Funding is provided to the states through a formula somewhat similar to that of the Hatch Act. Today, there are extension offices in nearly every county in the United States. They employ approximately 9,650 county agents and 4,650 scientific and technical specialists. The total CES budget is about $1.2 billion annually. Of that total in 1993, the states provided almost half the extension funding (46 percent), the federal government about a third (31 percent), and the counties about a fifth (19 percent) (1).

The research system must have public support and funding to function. It also must have the flexibility and the management capacity to reallocate scarce resources to new priorities, and to attract highly qualified personnel who can keep abreast of changing technological opportunities. Despite high social returns to public sector agricultural investments, the system has been the subject of criticism from internal and external sources. External critics decry the heavy research emphasis on agricultural productivity and the lack of research devoted to nutrition and food safety, rural problems, and environmental concerns. Criticisms have been directed at the perceived low quality of the research, the inadequate interaction of agricultural researchers with the basic scientific disciplines that underlie agriculture, and the limited role of peer evaluation in project formulation and review. In addition, public-sector budget constraints have frozen funding.

The public-sector agricultural research system is clearly being challenged from many directions. Whether the system can be revitalized and renew its historical commitment to solve the problems of U.S. society, or whether it becomes isolated and loses its credibility with the public remains to be seen. The remainder of this decade will be a period of significant stress and change within the agricultural research system.

## THE CHANGING ENVIRONMENT FOR AGRICULTURAL RESEARCH

As a catalyst to this change, internal and external pressures on the system will alter the function and structure of the system. Changing political support, resource base, and institutional frameworks will put pressure on the system to change (20,27).

### Political Environment

Historically, political support for the agricultural research and extension system has come primarily from the farm and rural population; as a result, the system has placed heavy emphasis on increasing agricultural productivity. However, agriculture's traditional base of support has been eroding steadily. Farm numbers and populations have been declining, and today more than 75 percent of the total U.S. population resides in metropolitan areas. Of the 435 members of the House of Representatives, fewer than 100 represent rural districts (27).

Public interest groups have become increasingly critical of the emphasis on productivity in agricultural research. The books *Silent Spring* and *Hard Tomatoes, Hard Times* criticized the system for its failure to address the problems of the environment, rural communities, and consumer needs. Environmental, consumer, and animal welfare groups have become increasingly active in recent farm bill debates. Additionally, these groups have challenged the universities themselves by bringing lawsuits on the use of public funds for productivity-increasing research. A lawsuit was brought against the University of California system, as an example, for using public money to develop a mechanical tomato harvester.

Increased public activism is indeed changing the climate in which the agricultural system conducts research. As a consequence, the Food Security Act of 1985 contained several conservation measures, and many more such measures were added in FACTA. Several environmentally oriented research initiatives, such as the groundwater initiative and the low-input sustainable agricultural initiative (LISA), were also passed. In addition, new institutions were established to focus on research and technology transfer assistance for developing new crops and new uses for traditional crops. Congress has specifically directed agricultural research funds to key areas to help the system adjust to these new priorities faster (21).

### Resource Base

Although total research funding has increased slightly over the past decade, agricultural research is generally underfunded when one takes into account its high rates of return on investment (see Chapter 6). For example, the states provide the majority of the funding for research at the SAES, and through the 1980s, state support increased. However, the recession of the early 1990s has constrained state budgets, resulting in few increases and in some cases declining state support for agricultural research.

USDA both disperses and consumes federal research funds. ARS accounts for about one-third of USDA research and extension expenditures, a share that has remained fairly constant over the years. Most of USDA's funds are spent on intramural research by ARS, ERS, and FS. Slightly more than a fifth of these resources are administered by the Cooperative Research, Education, and Extension Service (CREES). Most CREES funds go to SAES and other cooperating institutions.

USDA is SAES' second-largest single source of research funding. Historically, USDA funding has been in the form of block grant formula funds. Decisions about how these funds are allocated have been made at the local level. USDA funding has basically stagnated and barely keeps up with inflation. Increases in USDA funding primarily reflect congressional earmarking of grants for such concerns as water quality, nutrition, and integrated pest management and biological control research.

Research funds are not evenly distributed to all experiment stations. The experiment stations in 12 states (California, Florida, Iowa, Illinois,

Indiana, Michigan, Minnesota, North Carolina, Nebraska, New York, Texas, Wisconsin) account for nearly 50 percent of the total research funding available to SAES, nearly 70 percent of the USDA competitive grants, 61 percent of all competitive funds obtained from federal agencies other than USDA, and nearly 60 percent of all funding from industry support and product sales. All SAES have diversified their funding sources to some degree. However, the "have not" SAES rely primarily on traditional sources of funding (state and USDA formula funds), while the "haves" have to a greater degree diversified their funding sources (27).

### Technology Base

To continue doing high-level research, universities and federal laboratories need to keep abreast of new information and technologies. New biotechnologies and information technologies in particular are yielding powerful research tools that can be applied to questions in a wide range of scientific disciplines. Effective use of these technologies will require new funding, or a reallocation of funding from traditional research projects. The scientists who use these new research tools will need a thorough grounding in the basic scientific disciplines that underlie biotechnology and information technology.

The same 12 SAES that receive most agricultural research funds also receive most of the resources devoted to biotechnology research. Indeed, the concentration of resources in only a few experiment stations is even more pronounced for biotechnology than for all agricultural research.

### Legal Environment

The legal environment in which the agricultural system operates is changing. Congress has for the past 60 years expressly permitted intellectual property protection of new plants. In 1980, the U.S. Patent and Trademarks Office changed its interpretation of patent laws so that microorganisms and animals can be patented as well. More recent patent and trademark amendments gave universities, other nonprofit organizations, and small businesses the option, with few exceptions, to retain the title rights to any federally funded inventions that they developed.

Until recently, only a few institutions aggressively marketed the research of their faculties, primarily by licensing their technology to the private sector. Now, however, venture capital pools, technology development companies, and research companies with the goal of transferring technology and making money have become much more common. In addition, some universities now hold equity in or are otherwise involved with new ventures that invest in and commercialize the new technologies developed. These relationships between universities and the private sector, which are rapidly becoming more common, facilitate technology transfer, further beneficial relationships with private companies (sometimes with the goal of securing more research funding for the institution), and provide a way to better acquaint researchers with the practical application of their research results and with real-world problems. Researchers who create the new technology are now often given a share of the returns. Given these realities, conflict-of-interest policies have been designed to help ensure that intellectual property stemming from publicly funded research remains available to the public. Whether such policies are adequate is a central question, but they are becoming common throughout the university research system (21).

This wide range of changes was in part what led Congress to amend the research title of FACTA in 1990. USDA's efforts to implement the sections added to FACTA are discussed below.

## CONCLUSIONS

### Purposes of Agricultural Research and Extension

#### *Background*

In FACTA, Congress specified the purposes of agricultural research and extension: 1) to con-

tinue to satisfy human food and fiber needs; 2) to enhance the long-term viability and competitiveness of the food production and agricultural system of the United States within the global economy; 3) to expand economic opportunities in rural America and enhance the quality of life for farmers, rural citizens, and society as a whole; 4) to improve the productivity of the American agricultural system and develop new agricultural crops and new uses for agricultural commodities; 5) to develop information and systems to enhance the environment and the natural resource base upon which a sustainable agricultural economy depends; and 6) to enhance human health.

These purposes not only emphasize agricultural sustainability and rural social and economic concerns—they embrace the entirety of the agriculture, food, environment system. They emphasize major contemporary issues such as the environment and natural resources, economic and quality of life issues for rural America, new crops and new uses, competitiveness of the agricultural system, and human health. Ultimately, they lead to accountability. Unfortunately, even though these purposes provide overall guidance to USDA for research, they have not been implemented in any direct way.

### *Findings and Policy Implications*

**The Secretary of Agriculture has not established guidelines for USDA overall, and individual research units have not established guidelines for their programs.**

Given Congressional interest in purposes, and the value of being clear about them, a set of core purposes needs to be adopted by USDA for its research and extension programs. The purposes should be implemented through a set of guidelines and operating principles for program planning, priority-setting, and management, funding, and evaluation. One way of establishing purposes is to adopt the purposes established in FACTA throughout USDA.

Although the FACTA purposes are straightforward and appropriate, some other definitions of research purposes have emerged. The Congressional purposes might be considered in light of these other definitions. Alternatively, USDA could bring the several initiatives for purposes together into a unified whole. It need not, and should not, frustrate or obscure Congressional intent.

**A common failing with purposes is that they often are so general as to have little meaning.**

Purposes should be focused and precise, so that they can provide meaningful guidance for implementation. One approach is to focus on key contemporary national issues—the central feature of the Congressional purposes in FACTA. This approach has the advantage of focusing attention on issues for which research and extension can be expected to make a major difference. As such, measurable objectives and specific management actions and evaluations can be set forth.

Alternatively, USDA could provide support for generic research advancement across the wide spectrum of research and application for the agriculture/food/environment sector. This approach has the advantage of ensuring that the entire research system for the sector is supported and incorporated into planning, allocations, and evaluations. It has the distinct disadvantage of eschewing focus on pressing national issues and of being substantially featureless as to priorities and direction.

**USDA should decide whether to engage in a strategic and operational planning approach for focusing on key national issues.**

"Unified strategic research and applications/extension plans" for key contemporary issues of major national interest could be employed. The intent is to integrate all potential and actual participants into a unified strategy for addressing issues so as to make as rapid progress as possible through coordination and integrated planning. The present system has a low degree of coordination and integrated planning. The situation is discussed further in the next section on the National Research Initiative Competitive Grants Program, which would have to be one of the agencies participating in such plans.

**USDA should determine how best to engage the research agencies in addressing purposes and implementing them.**

At this writing, each agency determines how to implement purposes and with whom to relate. This approach has the advantage of being "inner-directed." It has the disadvantage of not necessarily securing the advantages that could (and likely would) accrue from collaborative work.

Alternatively, an integrated approach could be established among the agencies. Such an approach would have the advantages of ensuring that the best and most efficacious expertise and capacity are taken from each agency and woven into a coherent whole. Further, this approach involves all participants, which could lead to efficiencies and synergisms that might not otherwise exist. It has the disadvantage of being potentially cumbersome, diminishing long-standing autonomy, and leading to clashes among different institutional cultures.

**USDA must give more emphasis to after-the-fact evaluations.**

Virtually all emphasis is currently on planning specific categories of research and deciding how to aggregate resources to do the work. This approach is not sufficient. In recent years, national operational planning, which sets measurable objectives for key national issues, has become more popular. This is significant progress and demonstrates that operational planning can be done effectively. However, there has not been similar progress in outcomes evaluations, both to determine progress in achieving the objectives and as a guide for future program activity and also resource allocations.

The current system could be transformed to include after-the-fact evaluations of outcomes and impacts. Adopting such evaluations would continue the evolution of management of the system, be consistent with increased funding stringency and for improved performance of government effectiveness, and be a significant advance in adding key factors for allocating resources. It would, ideally, involve programmatic outcomes and impacts and also evaluation of management and operational effectiveness and of financial outlays.

## National Research Initiative Competitive Grants Program (NRICGP)

### *Background*

By authorizing the NRICGP in FACTA, Congress reaffirmed its commitment to funding research for foundational knowledge (that is, knowledge used as a basis for more advanced and applied research) through grants that are initiated by researchers themselves, peer-reviewed, and competitively awarded. Congress significantly expanded the authorization for funding competitive grants, specified six high-priority research areas, strengthened the peer-review and advisory oversight of the program, and authorized funds for multidisciplinary research.

Overall, the NRICGP has been implemented effectively. The priority research areas are appropriate and have received emphasis and funding within the constraints available. A number of steps, including advisory mechanisms, have been taken to ensure that the program is relevant to issues in the agriculture/food/environment sector. However, appropriations have been substantially less than authorized and required for adequate funding of the priority research areas. This dearth of appropriations has necessarily led to inadequate funding of key research areas, including natural resources, environment, and rural economic vitality. Notwithstanding the success of the program and its continuing promise and potential, there are a number of major implementation and funding issues and policies that should be dealt with during the next five years.

### *Findings and Policy Implications*

**USDA should reinforce the focus and emphasis of the NRICGP.**

The focus and emphasis of the NRICGP are on increasing foundational knowledge through grants that are competitively awarded. The grants are based on peer review, using the criteria of scientific quality and relevance to the long-term sustainability of the agriculture/food/environ-

ment sector. At the same time, pressure to engage the NRICGP directly with the applied aspects of contemporary issues could well divert the NRICGP from its original purpose.

If the current emphasis is maintained, the original intentions for the program are preserved. The NRICGP has shown that it is capable of discerning which topics are relevant and suit the needs of foundational research knowledge. This capability increases the attractiveness of USDA's mission for agriculture/food/environment to all the nation's scientists, a desirable national policy goal.

Alternatively, the NRICGP could be opened to more applied research. Such an action would significantly dilute, and ultimately likely preclude, the program focus for doing the kind of foundational research that needs to be done. It would also make the NRICGP just another funding vehicle for all manner of research already well represented in USDA's research portfolio. Should this happen, it would be reasonable to consider phasing out the entire NRICGP.

#### USDA should affirm and reemphasize the direction of the NRICGP on foundational knowledge.

The NRICGP has been asked, by direction and by funding actions, to focus on a broad array of research questions, priorities, and types. It must direct its efforts to fundamental and related mission-linked research to provide foundational knowledge for the agriculture/food/environment sector, including major long-term issues such as sustainable agriculture and water quality; and more specific topical issues, such as global change and monitoring for UV-B radiation.

The program has responded well to this mixture of demands and has, in the main, been faithful to its original intent. Because of earmarking and other stresses on the NRICGP, its efforts have, however, involved sacrificing some funds and responsiveness.

Consideration could be given to formally identifying the areas where foundational knowledge is needed and incorporating them into the NRICGP. Virtually every issue requires additional foundational knowledge. This appropriately falls within the NRICGP, and it is reasonable that the program be considered as the agency which should support it (but only if additional funds are provided for new programs and topics).

#### USDA should develop unified strategic research and application/extension implementation plans for contemporary issues.

The various programs and agencies that make up USDA's research portfolio operate independently from one another to a large extent, even though the programmatic issues that undergird and animate the program are common to all. Further, programs such as the NRICGP (along with major portions of the ARS and the SAES system) emphasize foundational knowledge, common to a number of the programmatic emphases and agency priorities. A set of unified strategic research and application/extension implementation plans for key contemporary issues would help to ensure that the necessary work gets done, related elements are coordinated with each other, and application of research results is focused and coordinated.

There are no such strategic plans at present. Continuing to operate without them means that the present system of agency autonomy and the current coordination system among the federal elements and among the federal, state, and private sector partners would suffice for addressing the issues. The current system has the virtue of avoiding undue centralization; it has the drawback of being largely uncoordinated and responsive only to the interests of the individual elements.

Increasing coordination among programs and agencies without formally creating such unified strategic plans is an alternative. This approach would use the current systems and would avoid creating yet more planning and associated institutional mechanisms. Some observers believe there is already more planning than necessary.

Creating a pilot or full program for such unified plans could be attempted. A pilot program

could focus on selected key topics such as water quality, pest management, and sustainable agriculture. To make the program work (and make it attractive to the participants), planning could be followed by funding to implement the program. The risk is that the plans would be simple listings and recitations of work under way. That result in itself would be satisfactory if it were linked to desired outcomes, but would be unsatisfactory if merely the status quo were otherwise continued. The aim is to promote greater efficiency and effectiveness by leveraging and coordinating work and funding, and by being clear about and dedicated to securing meaningful outcomes within specified time periods.

**The NRICGP is not funded sufficiently.**
Appropriations for the NRICGP are currently about $100 million, even though the authorized level is $500 million. The availability of quality proposals is more than double the current funding level, and there is obvious programmatic need for foundational knowledge from the program. The return on research investments is high (20 percent or more). Without additional funding and continued growth of funding, there is every reason to believe that the program will languish at its current level, and that a major opportunity for securing both knowledge and researchers for the sector will be lost.

**Earmarking and targeting NRICGP funds is counterproductive.**
Incorporating earmarks and other targeting of NRICGP funds would continue current practice. Over time this practice will destroy the integrity, and ultimately the fabric, of the program: the demands for funding for major issues are so strong and pervasive that there is no obvious way to limit earmarks and targeting in a systematic way. Earmarks address applied issues that are the focus of other parts of the research portfolio, not the NRICGP. Most important, earmarks do not provide the foundational knowledge that the agricultural sector needs.

To ensure the integrity of the program, all earmarking and targeting should cease. If it is believed that the NRICGP is appropriate for doing some or all of the work on a topic, the program staff should be consulted to determine how the interests might be met *within the program structure* and what funding would be required. Responses to earmarks have shown that this would be effective.

## Sustainable Agricultural Research and Extension

### *Background*

Congress has been interested in sustainable agriculture since at least 1977, when it first defined the new phenomenon as an effort to: 1) satisfy human food and fiber needs; 2) enhance environmental quality and the natural resource base upon which the agriculture economy depends; 3) make the most efficient use of nonrenewable natural biological cycles and controls; 4) sustain the economic viability of farm operations; and 5) enhance the quality of life for farmers and society as a whole. Congress' interest grew out of a number of different but largely related concerns: emerging recognition that soil and water resources were being degraded; adverse environmental and human impacts of chemical pesticides; the steady decline of the economic and social vitality of the rural and farming sector; steadily decreasing farm numbers and growing evidence of increasing proportions of larger farming operations and part-time farmers; and increased competitiveness in agricultural production. Congress also aimed to address the unease of some observers who argued that these concerns had received only limited if any attention from USDA, or from the land-grant university and state agricultural research system. This issue was addressed further in the Food Security Act of 1985 (the 1985 farm bill) by Congress' intention that USDA determine how to do more research to preserve natural resources and environmental quality concurrent with ensuring agricultural productivity. Through FACTA, Congress went on to establish 1) the Sustainable Agriculture Research and Education (SARE) program and 2) more specific emphases for a

sustainable agricultural economy and for the natural resource, environmental, and social and economic quality of agriculture and the rural sector, by altering the research title.

### *Findings and Policy Implications*

#### There is little effective leadership and management for sustainable agriculture in USDA.

A major criterion for the success of any program is that it be supported strongly and clearly by senior policy leadership, and that a management structure be established that is both effective internally and accountable externally. At present, such actions have not been taken, although a major initiative to this effect has recently been established, reporting directly to the Deputy Secretary.

#### USDA should determine the extent to which sustainable agriculture should receive emphasis, planning, management, and funding throughout the department on a *systemic* basis.

The critical issue is whether sustainable agriculture—or other major issue comparable in scale and substance—should receive *systemic* leadership, management, planning, funding, and oversight and accountability. Or, alternatively, whether such issues should receive attention based solely on the interests and perquisites of individual agencies and individuals. Advantages of the former include integration, efficiency, cost-effectiveness, and increased accountability for results. A particular advantage is that such an approach would provide for a systemic analysis of possibilities and encourage cross-boundary thinking and collaboration. Possible disadvantages include ineffective, possibly misdirected "top-down" leadership and management; insufficient scientist and extension motivation and commitment; and the possibility of catastrophic failure from "central planning" or its variants. An almost certain disadvantage is the lack of significant systemwide operational planning (in contrast to thematic and budget acquisition planning, which is done in USDA).

The advantages and disadvantages of the alternative approach are essentially the obverse of those of the systemic approach. Possible advantages include minimizing or even avoiding the disadvantages of the systemic approach. Possible disadvantages are lack of attention to and incomplete coverage of sustainable agriculture; lack of involvement of key partners; and cost-ineffectiveness and lack of research focus.

If the systemic approach is taken, a number of options can be considered. A useful option would be to build and expand on the current initiative. Another useful option would be to create an *integrated, unified strategic research and applications plan*, as outlined previously in the section on the NRICGP. If that option is pursued, most if not all of the disadvantages outlined above would be avoided.

#### Funding issues should be engaged.

There seems little reason to believe that sustainable agriculture will not benefit from steady increases in appropriations, as a consequence of the importance and priority for sustainable agriculture and of the success to date. However, if increased funding is to come, it will most likely be at the expense of another research area. Such an action would have its own limitations. For example, if the funding were taken from the NRICGP, a major venue for attracting scientists to the fundamental research questions that underlie sustainable agriculture would be destructively compromised.

Congress or USDA could redirect funds from the federal and state partners to be dedicated to sustainable agriculture. While such an action may be satisfactory for federal agencies, it will likely be resisted strongly, and successfully, by state partners, given past history. A more focused, incentive-based system seems more appropriate.

Redirection is most effectively and directly done through increasing the competitive grants programs for both the SARE and training programs. Given the constraints on formula funds and the decentralized traditions of allocating and using them, expanding the competitive grants in

these two programs is the more efficacious approach. Much national experience through the science and technology sector shows that focus and direction are easily and positively established for competitive grants, and proposals of highest merit and relevancy are most readily assured of being funded. Further, the current grant programs are successful to this point and give every indication of being so in the future.

## Alternative Agricultural Research and Commercialization

### *Background*

Through FACTA, Congress gave major attention to the broad topic of new uses and products for the first time. Its action reflected widespread national interest in diversifying the agricultural production sector beyond traditional commodities; expanding the economic vitality of the agricultural sector; and expediting technology transfer from the laboratory to commercial use.

Two major initiatives were taken by Congress: 1) establishment of a program and organizational structure for Alternative Agricultural Research and Commercialization (AARC) and 2) establishment of the Agricultural Science and Technology Review Board. AARC assists the commercialization of nontraditional, nonfood products through product development and prototyping, marketing and economic analysis, precommercial development, early-stage manufacturing and testing, and product introductions. Its emphasis is on precommercial development and testing, marketing, and pilot production, rather than on research and early-stage development. This is done because it is currently believed to be the most cost-efficient way of expediting commercialization. The major research function, appropriately, is left with public or private research and development agencies. Given that the focus is on business development and product commercialization, inherently private sector rather than public sector activities, such an emphasis is appropriate. AARC's central financial resource is a revolving fund initially provided by Congress to make investments to assist commercialization of new products. Repayment is through a percentage of future sales or equity in the company.

The Agricultural Science and Technology Review Board was established to provide technical assessment of agricultural issues and to consider the impact of technologies on agriculture and the social and economic well-being of communities. Like AARC, it complements Congress' intent in encouraging the development of technologies friendly to the environment, people, and communities. However, both of these new institutions have suffered from inadequate funding.

### *Findings and Policy Implications*

#### Funding issues for AARC should be addressed.

By any measure, this program is a significant element in USDA's overall program, and a potentially significant adjunct to the department's constituent agencies. As such, its future needs to be addressed forthrightly, and commitment must be made to its success. A key element is funding. Based on the data available, and absent the ability at this point in time to make conclusive judgments about the efficacy of its financial investments, AARC's funding needs to be sustained at least at the present levels, and preferably increased substantially to add to and diversify the investment portfolio. With the right investments, the program should reap a profit that can be continuously reinvested in additional technologies and products.

If funding continues at current levels, it would mean appropriations of about $8–10 million per year. Such appropriations would be fiscally prudent (and conservative), given the early stage of the program and the need for determining analytically the success of the project selections and investment decisions. However, this relatively low level of funding also indicates to the industry that AARC will "go slow"—even though there is evidence that the program is working well and could be of greater benefit and impact with additional funding.

As an alternative, the program could be expanded commensurate with current staff and project availability. At present, the program can be expanded by two- to four-fold without an evident decline in quality, according to staff analysis. Modest expansion of the appropriations to $15 million for FY 1996 and to $25–30 million over the following two years would be reasonable. This would bring the total in the revolving fund to a little less than $100 million.

**USDA should determine the optimum location and functions for technology review and assessment.**

At present, this important function rests with the Agricultural Science and Technology Review Board established by FACTA, which is outside the environment of the operating USDA agencies (e.g., ARS and ERS) and virtually an integral part of another advisory body (the Joint Council for Food and Agricultural Sciences). If close involvement between research and development and technology review and assessment is desirable, as seems appropriate for most circumstances, it is also appropriate that this review and assessment function be brought philosophically and operationally closer to the operating agencies. Alternatively, if review and assessment are to be something akin to a "conscience" for the operating agencies, it is reasonable to suggest that at least some of the function be done outside as at present, but also with input from, the operating agencies.

At a minimum, technology review and assessment must be emphasized throughout USDA. Without such emphasis, review and assessment will always be considered second-hand activities that are not directly important to the operating program units.

The present situation keeps the board in relative obscurity, without any real opportunity for interaction with the operating agencies. It does, however, provide opportunity for independent assessment.

Alternatively, the board could be folded into the Joint Council for Food and Agricultural Sciences. Such a plan has the virtue of administrative simplicity and connection of assessment to the review, oversight, and advisory functions of the council. It does not address the fundamental issue of disconnection from the operating agencies.

**USDA should create technology review and assessment functions in each operating agency, and also create a significant coordination and collaboration function to work among them in a synergistic way.**

The reasons for this approach are derived from the above rationale: importance, integration into operating units, coordination as appropriate with related units, and a USDA-wide approach.

## Financing, Organizing, and Managing Agricultural Research

### *Background*

Agricultural productivity has grown rapidly in the United States relative to productivity in the general economy. Many attribute a good portion of this growth to public-sector agricultural research and extension, which operates primarily through land-grant colleges and USDA research agencies, in a system that was introduced over a century ago. In recent years, the agricultural sciences have increasingly been asked to do more with less. Questions have been asked about whether the old research institutions are still needed, and about how they should adapt to accommodate changes in science, in scientific institutions, in society and social attitudes, in government, in agriculture itself, and in the general economy.

To achieve the greatest gains for society as a whole, a fundamental rethinking of the basis for and approaches towards *financing*, *organizing*, and *managing* public-sector agricultural research is needed. Most previous commentators have called for more federal dollars for research—but that is only a part of the solution. Other public policy mechanisms can (and should) be used, along with taxpayer funds, to increase the total private and public investment in agricultural research, and to promote a socially profitable

mixture of research programs (from basic to applied research; across disciplinary areas; across commodity-oriented research programs; in terms of its geographic relevance; and between environmental and other natural resource issues). The policy analysis must include a consideration of different funding mechanisms—how they affect the cost of research (including who bears the cost in relation to who benefits), and how they affect incentives for private research and development.

A rethinking of policy extends beyond the boundaries implied by the current institutional structure, dominated by the SAES and the USDA intramural laboratories. Such an effort means considering greater use of in-between alternatives, such as regional research institutions, and allowing open competition among all of the different institutions, where appropriate, for the available funds.

An integrated, rather than piecemeal, assessment of the full range of public policy issues related to agricultural research is required. Decisions must be made concerning 1) the relative responsibilities of the major research participants for research (for example, fundamental, applied, developmental; generic or specific; geographic emphasis; and the like); 2) the amount of resources (federal, state government, and other) to allocate to the research; 3) the way research is funded; 4) the types of research undertaken; 5) the institutional structures related to allocating resources and conducting research; 6) the mechanisms for communicating research results; and 7) the relative roles for the major participants including federal and state governments, universities and research institutes, and the private sector. All of these are mutually dependent, and they should be thought through together. Making changes in one element (for instance, increasing or decreasing federal support for research, or the responsibilities of state governments compared to the federal government for funding locally and regionally significant research) without thinking through the implications for other elements of the system (incentives and institutional mechanisms for industry-based research support, for instance) could have undesirable and unforeseen consequences.

### *Findings and Policy Implications*

#### Economic efficiency should be stressed.

The rationale for intervention leads to a single criterion for designing public policy for agricultural research and for organizing and managing the institutions that are used to implement that policy—economic efficiency. This would permit the incorporation of externalities, such as environmental and social effects, into the evaluation of research funding. According to this criterion, the evidence suggests that the total (private plus public) investment in agricultural research should increase.

#### Alternative financing methods should be developed.

Financing can be made more efficient—in terms of total quantity of research resources, lower costs of raising the revenues, and greater allocative efficiency. As but one approach, increased use of industry check-off funds is a good way to do this. The development of this and comparable types of arrangements could be stimulated appropriately by the provision of tax incentives and matching grants from state and federal governments.

#### Alternative organizations for agricultural research should be created.

Research could be organized more efficiently by developing alternative institutions to bridge the gap between state and federal jurisdictions, and through greater use of economic efficiency criteria to determine the balance between different types of research organizations. The current system emphasizes two types of institutions (for example, SAES versus intramural USDA institutions) funded by a combination of state and federal government monies. There is a potential to develop new institutions serving subnational multistate regional or commodity interests, on the basis of efficient research jurisdictions, with a mix of private and public sector funding.

**Management of agricultural research can be improved.**

Finally, the management of research can be improved by substituting economic incentives for central directions, by clarifying the economic objective of research and ensuring that resources flow according to the achievement of that singular purpose, and by using competition rather than committees to allocate resources. To achieve the greatest social payoff from public-sector research, the current arrangements (formula funding and special grants for extramural research, and an earmarked pot for intramural research) must give way to a greater use of competitive grants.