Chapter 3

Problems and Issues Challenging Agricultural Research and Extension

The twin forces of a broadening of research problems facing American agriculture and the advent of a new era in technology pose significant challenges to the research and extension system. Can the system readily adapt to this new agenda?

Evidence exists that it will be difficult. For example, researchers who want to adopt plant-cell biotechnology need education and training in the basic fields that underpin this technology. Cellular physiology, biochemistry, genetics, and microbiology are not generally found within colleges of agriculture at land-grant universities.

This problem in agricultural education notwithstanding, the application of biotechnology to agriculture will proceed at a rate commensurate with its benefits and with the abilities of the private sector to market a product both in the United States and elsewhere. Because many businesses are now global, adoption rates will be similar worldwide (18).

There are several indications that adoption of biotechnology may bypass the traditional agricultural research and extension system if changes are not made:

1. At least one-third of the Federal funding of agricultural research is granted by Federal agencies outside of USDA (Appendix Tables B-1 and B-2). Therefore, USDA is no longer viewed as the only agriculture research-granting agency.

2. Ten of the 57 state agriculture experiment stations received the bulk of Federal funds for biotechnology from research agencies other than the USDA (Appendix Table B-3). These 10 experiment stations are the same ones that have basic science depart ments within the associated colleges o agriculture. A direct relationship seems to exist between an institution's ability to cap ture Federal grants for biotechnology and the strength of its basic science com ponent.

3. A survey in 1987 concluded that 40 percer of the Ph.D.'s working in agricultural re search did not graduate from a college c agriculture. At least 8,000 active agricul tural scientists earned Ph.D.'s outside c applied agricultural disciplines (12).

4. The agriculture private sector seems to b granting more research funds to educa tional institutions other than colleges c Agriculture. Land-grant universities ar receiving funds for basic science researc but most recipients are faculty in the co' lege of Arts and Sciences, not faculty i colleges of Agriculture (9).

An argument can be made that this situa tion does not need fixing, that a much broade base for agricultural research is evolving However, this is risky. There is a lag tim between "the publication of basic scientif work and its development into a technolog by applied agricultural public and private se tor researchers. Without a close workin relationship between basic scientists and al plied researchers on U.S. campuses and i Federal agencies, information transfer an technology development will be no faster her than anywhere else researchers read basi scientific journals. The United States will no obtain a lead-time advantage for its inves ment without on-campus or inter-agency in tegration of basic and applied research, an technology transfer that operates in partner ship with research development.

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In addition, scientists unfamiliar with agriculture may work on problems irrelevant to agriculture's needs or develop inappropriate approaches to solving the problems of agriculture. Faculty in fundamental sciences are not necessarily concerned with practical applications of their research and experiments, and they are frequently unaware of the real needs of agriculture.

A strong, responsive agricultural research and technology transfer system is also needed to complement private sector research. The research investment by the private sector is substantial today, and the private sector operates quite independently of the land-grant and USDA research establishment. The United States cannot afford to have a public sector research component that lags behind the private sector, one relegated to a role of simply reacting to, reviewing, or second guessing private sector research. What is needed is a publicly supported system that provides new methods, products and technologies.

For one thing, the private sector will use biotechnology primarily to protect and extend its investment in current products. This is a natural and predictable response. Little incentive exists for a chemical company to develop a plant that needs few chemical inputs. Similarly, little incentive exists for a seed company to develop a plant with drought tolerance but reduced yield. This is merely to recognize the purpose of business and the need to protect shareholder values. Publicly supported research needs to provide the technical foundation for a continuous new array of technologies to reduce input costs, to develop new uses of existing crops as well as new crops, and to help make agriculture more environmentally benign.

THE FUNCTIONS AND CHALLENGES OF RESEARCH AND EXTENSION

Providing a strong public sector research and extension system means focusing on the continuum of technological change. The process of achieving technological change in agriculture involves three basic steps, each a component of the research and extension system:

1. basic research- discovery of new knowledge, concepts, and relationships;

2. applied and developmental research:

   - development of ideas, concepts, and relationships into products (outputs of technology);

   - adaptation of new technologies to various agroecosystems; and

   - maintenance of newly achieved productivity in the face of evolvingpests, disease, decline in soil fertility, and other factors (sometimes referred to as maintenance research).

3. adoption of products or processes (transfer of technology).

Discovery is the primary function of basic research. Most basic research has traditionally been done in the public sector. There seems to be a general assumption that the private sector will not support sufficient amounts of high risk basic agricultural research because that research is unlikely to yield a near term payoff. However, this assumption is now being challenged by large private sector investments in biotechnology and information technology.

Developmental and applied research is conducted by both the public and private sectors. The marked increase in the quantity of applied private sector research has led some to suggest that the public sector support for agricultural research might logically be reduced. Such a suggestion, however, is overly simplistic. Most private sector applied research is aimed at development of ideas, concepts, and relationships into new products. The private sector directs little effort to the adaptation of new technologies to a specific agroecosystem or to defense of newly achieved productivity gains (maintenance research) (14, 17).

The function of encouraging technology adoption traditionally has been shared by the public and private sectors. In the public sector, extension educators work directly with farmers to test and demonstrate the usefulness of new products. Private firms tend to concentrate their adoption strategies on more conventional promotion and advertising strategies.

The effort and resources required to achieve a technological breakthrough, as a general rule, increase over time. This is true because the simpler problems naturally tend to be solved first. More difficult problems require more complex tools and analysis and, thus, a larger commitment in research and extension time, effort, and resources. This is becoming clear as agriculture enters the biotechnology era. To achieve the benefits of this era, large investments must be made in basic research and research techniques. Laboratories and equipment will be more complex and expensive. Scientists with modern biotechnology research skills must be trained for agricultural research, and existing agricultural scientists will need new training. Technology users will also have to be further educated if they wish to adopt and use the more complex new technologies effectively.

The research and extension system thus faces numerous challenges. These evolve around five issue areas: mission, structure, planning, priority setting, and funding of the AR&E system.

MISSION

A recent General Accounting Office (GAO) review of USDA management found that the Secretary of Agriculture faces a formidable task: to mobilize a large work force in 36 USDA agencies to implement policies and programs under rapidly changing conditions in the face of many internal and external constraints. Despite dramatic changes in the food and agricultural sector, USDA’s basic organizational structure has changed little. Its agencies are tradition bound and highly resistant to change. This rigidity and lack of flexibility, the report goes on to say, reduce the ability to redirect the allocation of scarce human and financial resources within the Department (22).

UOSDA’s stucture has served its clientele well m a period dominated by domestically oriented agricultural policies. However, when faced with more complex problems and changing international conditions, USDA’s great size and structural diversity present problems. The agency will have difficulty directing the growing number of important cross-cutting issues that demand a higher degree of interagency, intergovernmental, and interdisciplinary cooperation than has previously been required.

The GAO review concludes by stating that to begin to address these weaknesses, the Secretary needs to develop and clearly articulate an agenda for USDA focused on important cross-cutting issues and on improved management systems. The agenda should include a statement of 1) goals, 2) actions to achieve the stated goals, and 3) management systems to monitor implementation and evaluate results against desired outcomes.

Without such an agenda, it is not surprising that no clearly defined or written mission or policies exist for the AR&E System, USDA Science and Education or related programs. Within USDA, individual research agencies have mission statements but most are not comprehensive. A mission statement should set out the goals and objectives of the organization and strategies to achieve them. Critical to any mission statement is a set of policies that define procedures, responsibilities, authorities, and operational factors that relate to the fulfillment of the mission and to “day-to-day” activities. There must also be a process for keeping the mission, policies, and clientele updated regularly. The mission statement for the Agricultural Research Service comes the closest to meeting these criteria.

Perhaps because they lack similar statements, some agencies seem to be “all things to all people.” Without mission and policies, organizations can only express vague plans and priorities and it is difficult to define their clientele. The respective research organizations have a hard time understanding clearly the roles, responsibilities, and clientele of their sister organizations. Likewise, it is difficult for the public, industry, and technology-transfer organizations to understand and support agricultural research.

A mission statement is critical for Extension. Currently, its programs encompass agriculture and natural resources, home economics, 4-H youth, and rural community development. As the number of U.S. farms decline and as urban populations expand, Extension’s clientele has become more urban in its orientation. To many Extension has become an institution trying to be “all things to all people.” This development has led to friction between Extension and its traditional agriculture clientele in the 1980s (15).

Congress in the 1985 Food Security Act directed a number of questions at the Cooperative Extension System. Among these were: a) what is Extension’s mission and who are its clientele, b) how should Extension be organized and structured, c) what is its role in technology transfer and applied research, and d) how does Extension develop new educational methods to meet the needs of its traditional clientele on declining numbers of mid-size farms. These questions were particularly directed at state programs because they are responsible for program delivery.

If Extension is to escape the "all things to all people” label it will need to develop a mission statement and criteria that will limit its programs to definable priorities and goals. Extension’s traditional focus has been agriculture and natural resources, and it is in these areas that Extension has made its greatest contributions in the past. As each state becomes more urban, Extension resources are increasingly drawn away from farmers and rural families. Extension must decide whether this trend will continue. If so, the programs displacing agriculture and natural resource programs should have the same quality research and knowledge base, and they should have a high probability of making an impact on high priority problems.

Mission Issues

In defining the mission of the AR&E system, USDA Science and Education and related programs several questions arise. Some of the them are:

1. Can mission statements and attendant policies related to research and extension be developed for USDA agencies (S&E, CSRS, ES, NAL) and other agencies receiving Federal funds?

2. How can the mission statement be used to assist in setting priorities, allocating resources, and defining clientele?

3. Who should be involved in development of specific missions, policies, and identification of clientele?

4. What management structure should be responsible for maintaining and updating mission and policies?

PLANNING

Effective planning allocates available resources to priority programs, problems, and issues. Within Science and Education at USDA no short- or long-term plans exist to coordinate the activities of SAES, ES, ARS or NAL (7). Nor are there plans to coordinate the activities of these agencies with those of other USDA agencies such as ERS, FS, or the regulatory agencies. For example, in the report *Enhancing the Quality of U.S. Grain for International Trade,* OTA identified research, extension, economic, marketing, transportation, and regulatory strategies to meet the goal of enhancing quality. But no apparent plans, incentives, or mechanisms exist for coordinating the expertise from Federal, state or private research and research-related groups to address international trade or similarly complex problems.

Occasionally, agencies develop joint functional plans to address a problem. For example, there are joint plans involving ARS and ES in a technology transfer system. Similar planned programs between ARS and NAL relate to dynamic information storage and retrieval systems. ARS is the only S&E agency that has maintained an updated six year program plan that covers all research programs in the agency. This is complemented by a set of agency policies that assures the maintenance of a functional planning system.

Science and Education at USDA has established a Board of Directors for the purpose of developing and approving plans for the allocation of competitive grants for national research initiatives within USDA (to be discussed later). The Board is comprised of the administrators of ARS, CSRS, ERS, ES, FS, and NAL; it is chaired by the Assistant Secretary for Science and Education. This is clearly a step in the right direction for effective planning. It is, however, only for the purpose of allocating competitive grant funds. The Board does not address the planning and allocation of intramural and other grant funds in the system. It also does not formally coordinate with other Federal food and agriculture research funding agencies such as NIH and NSF.

There are a number of planning activities at state, multi-state, or regional levels but these usually relate to program implementation, e.g., the Integrated Pest Management Program. Sometimes plans are made by individual scientists or groups of scientists without authority over resources. Commonly, there is a great deal of planning without the necessary commitment of resources for goal development, implementation, and monitoring. Plans are not effectively impacting key decision points locally or nationally.

Extension has historically not been a top-down planning organization. Much planning is done at the local level through advisory committees. Hence, local priorities and needs have been expressed more than national ones. National planning takes place as local and state needs are consolidated and incorporated into a framework of issues likely to receive national attention for funding. There has been little interactive planning between Federal and state partners (15).

Planning Issues

To develop effective planning within the AR&E system, a number of issues need to be addressed. They include the following:

1. How can meaningful short- and long-term plans for research and extension be developed?
2. How can local and state priorities be adequately reflected in national issues?
3. How can accountability be built into the planning process to assess progress towards goals and objectives?
4. How can a multidisciplinary approach towards planning be accomplished?
5. Can plans be developed that identify program changes (reduction or expansion) as budgets increase or decrease?
6. What is the role of the Joint Council and Users Advisory Board in the planning process?
7. Who (which groups or individuals) should be responsible for initiating planning?

PRIORITY SETTING

In a system that does not have a clearly defined mission or effective planning, it is not surprising to find a lack of specificity and clarity in stated priorities. Within USDA there are no set Science and Education priorities. Individual S&E agencies have identified their research and research related priorities independently of one another, and each has developed its own justification. A number of groups have laid out priorities for the system, including the Joint Council, Users Advisory Board, Experiment Station Committee on Policy, Extension Committee on Policy, and Resident Instruction Committee on Policy among others; but no explicit agreement exists among them nor was it sought. No priorities are assigned the stated needs for research and extension funding, facility renovations and new equipment. Within S&E, no apparent efforts have been made to set *broad* priorities (such as export marketing, or conversely, conservation of resources), or to prioritize sub-problems (such as food safety or soil erosion). In addition, problems have not been defined in terms of measurable goals. Thus, recognition of water quality as a problem has not led to questions like “how can nitrate levels in well water be reduced by 25 percent by 1993?” And there is little, if any, indication of the program changes that would be necessitated by lack of funding.

Extension’s response to the concerns raised in the 1985 Food Security Act (discussed earlier) was a strong attempt to develop priorities. The effort was sponsored jointly by Extension Service and the Extension Committee on Policy (ECOP). It emphasized the efficiency, accountability, and clarity of Extension’s mission and its goal of making innovative program changes to meet the issues of the 1990s. Issues were identified with input from clientele and Extension staff across the United States. A number of hearings were held around the nation to secure additional input. The result of this process was the publication of the report *Cooperative Extension System National Initiatives* in conjunction with a national seminar that signaled Extension’s commitment to the changes identified in the report and that outlined its plan of action.

The nine identified initiatives in the report encompass programs already offered by Extension. They identify critical issues and problems, describe what Extension will do, provide potential impacts of successful implementation, and provide examples of model programs.

The nine initiatives are well motivated and a step in the right direction. However, taken together they are too all-encompassing. The first and foremost concern is funding for initiative programs. It is highly unlikely that new Federal funds will be forthcoming in the near future because the executive and legislative branches are dealing with the difficult budget deficit problem. Many state and local governments face similar budgetary constraints. It may well be that funds will have to be reallocated to accomplish even part of the new initiatives, particularly if budgets decline.

Another concern is that no process exists to reallocate funds to the most critical issues. Currently, all nine initiatives are treated with equal weight. Some mechanism is needed to force priority setting among and within initiatives and to reallocate resources to those of higher priority. The initiatives assume that local priorities are the same as national ones. Criteria and mechanisms are also needed to balance local and state priorities with national ones and to resolve differences if conflicts arise. A critical question is whether these initiatives are intended to direct resources from a national viewpoint or merely to provide a descriptive framework into which states can fit their self-determined programs. In the absence of a mechanism to force action in guiding and planning resource use, the latter seems to be the outcome whether or not it is the intent.

Questions arise about the specificity of the goals in several initiatives and about whether the impacts described can be measured in specific and meaningful terms. At present, no process exists to reevaluate priorities and reallocate resources to meet new and emerging priorities. Evaluations should estimate what impacts the initiatives have had and indicate whether goals have been reached and problems solved. They should serve as a basis for program adjustments or termination o: programs and reallocation of resources. This process is critical if the initiatives are to reach their full potential as a priority setting and planning tool.

Because priority-setting efforts are uncoordinated within the AR&E system, extension and research priorities do not match well A comparison of the extension initiatives, research priorities and Joint Council priorities are shown in Table 3-1. Wadsworth (1989) concludes that "... over half of the Extension Initiatives will not be supported by research priorities." Wadsworth attributes the difference in priorities to the mismatch between the mission-orientation of extension and the disciplinary/basic research orientation of the experiment stations. There is evidence that the Joint Council attempted to bridge the gap between research and extension. It is not clear, however, what changes were made in either extension or research priorities after the Joint Council report was released.

Priority-Setting Issues

To develop clearly stated and specific priorities for the AR&E system, a number of questions arise. They include the following:

1. 1. Is it possible to develop a single set of national priorities for the research and extension system indicating the role, responsibilities, commitments and funding needs of each component?

2. Should priority setting be a top-down, bottom-up or a peer determined process, or some combination of these?

3. Can priorities be set for national, regional, or local needs without the benefit of clearly

stated missions and policies for the research and extension system?

4. What mechanisms and criteria should be used to rank one priority over another?

5. How can national priorities be incorporated into state and local programs?

6. How can extension priorities be incorporated with those of agencies with research and education responsibilities?

STRUCTURE

Structure should facilitate the carrying out of mission, planning, and priority setting of any institution. It is important to ask from time to time what purpose an institution should serve and how best to structure it to fulfill that purpose.

The present AR&E system is decentralized, being composed of Federal, state, and local partners. Decentralization has advantages and drawbacks. One advantage is responsiveness to local problems. However, a major drawback of a decentralized system is the difficulty of coordinating programs to address problems that extend beyond county, state, or regional boundaries. It is also difficult to evaluate local and state efforts in terms of national problems such as the competitiveness of the food and agriculture sector, improvement of the environment, and safety of the food supply. With a decentralized system, changes are not easily made at the national level. This may be in part because funding is partitioned into Federal and state appropriations, formula funds, competitive grants, special grants, and private funding. Local organizations may also resist structures and courses of action that are seen as weaken-

Table 3-1-Research Priorities, Extension Priorities, and Joint Council Priorities

NARC Research Priorities	Extension Priorities	Joint Council priorities
Water Quantity and Quality	Water Quality	Improve Water Quality and Quantity
Biotechnology	Competitiveness and Profitability of American Agriculture	Enhance Competitiveness of Agriculture
Genetically Improved Plants	Improving Nutrition, Diet and Health	improve Understanding of Diet, Human Nutrition and Health Relationships
Soil Productivity	Revitalizing Rural America	Enhance Rural Economic Development
Pest Management	Alternative Agriculture Opportunities	Expand Biotechnology and Its Applications
Food Processing and Preservation	Conservation and Management of Natural Resources	Develop Agricultural Production Systems Compatible With the Environment
Agricultural Product Diversification	Family and Economic Well Being	Genetically Improve Economically Important Plants
Animal Efficiency in Food Production	Building Human Capital	Improve Safety and Quality of Food Products
Animal Health and Disease	Youth at Risk	Investigate Potential Effects of Global Climate Changes on Agricultural and Forest Productivity
Food and Nutritional Health		Nurture the Nation's Talent Base in Food and Agricultural Sciences
		Enhance Control of Agricultural and Forests Pests and Diseases
		Develop New and Expanded Uses For Agricultural Products

Source: Wadsworth, H. A., "opportunities for Public Policy Education in the Extension Initiatives." September 1989, and Joint Council on Food and Agricultural Sciences, Fiscal Year 1991 Priorities for Research. Extension. and Higher Education, June 1989.

ing local control or as potentially less responsive to perceived local needs.

There has been increasing competition and division within the historical management structure of the research complex. The situation has worsened as research budgets have declined, both within S&E at USDA and within universities. Little cooperation exists between ARS, CSRS, and ES within USDA and many colleges of Agriculture rarely cooperate with other colleges such as Arts and Sciences within the same university (7, 9).

This problem might be solved by prioritizing problems of national significance and strengthening those structures, mechanisms, and policies that facilitate the effective allocation of resources to solving those problems. Mechanisms will also be needed to preserve the strength of local and state programs and provide enhanced support and leadership from the Federal level.

New structures and mechanisms for technology development and transfer to the private sector are evolving outside the AR&E system. This is having an impact on the system. Extension's knowledge base traditionally has been drawn from the state experiment stations. This knowledge base is shrinking as state experiment stations and the USDA Agricultural Research Service place increased emphasis on "basic" research (15, 17). As biotechnology is becoming more important in research, considerable sums of venture capital have been invested in private biotechnology firms for development of new products. All of this has left Extension out of the research and problem applications loop.

Changes in technology and technology development are taking place very rapidly. Technology is international in scope and there is fierce competition for control. It is imperative to reexamine and reevaluate the structures and mechanisms that tie Extension to research and technology development in the public as well as the private sector. Extension's relationships with the private sector need to be reexamined if Extension is to link itself to the emerging mechanisms that will control the development of new technology and knowledge. In particular, Extension needs to be involved in the commercialization of new technologies and knowledge, not only for the purpose of identifying new products and concepts that could be used in education programs, but also to assist actively in testing, evaluation, and directing these products and concepts to critical problems and issues. Much research is of no use until it is transferred into a usable product that can be incorporated into a strategy for solving a problem. Extension can and should be of valuable assistance in this process.

The 1985 Food Security Act clarified the role of extension in conducting applied research. Although much applied research is being conducted by extension professional staff, with more planned, resistance has been encountered from Federal Extension and experiment station directors who believe that this is not an appropriate role for extension. In any case, the adequacy of resources for this purpose is questionable.

An applied research component to Extension is essential, however, if its programs are to be integrated with research developments. The role of applied research in enhancing cooperation between experiment stations and extension services was addressed by a joint Experiment Station Committee on Organization and Policy (ESCOP) and Extension Committee on Organization and Policy (ECOP) in 1988. It concluded that an applied research component would allow Extension to link new technologies and knowledge with its education programs. It recommended that:

a. The College of Agriculture or equivalent units at land grant universities develop mechanisms to enhance joint program development, planning, priority setting, and evaluation. These should include but not be limited to task forces, budget initiatives, and publications/media programs.

b. The use of joint appointments between experiment station and extension be further encouraged.

c. The ultimate basis for coordination, integration, and quality control of extension research be formal projects subjected to the same peer review and evaluation and reporting requirements as those of experiment stations.

d. The extension efforts of experiment station scientists be integrated into extension planning and priority setting mechanisms and be subjected to peer review and reporting requirements as are other extension programs.

Extension personnel need further training if they are to understand and use the advances in biotechnology and information technology in developing programs for clientele. Structural changes are also needed to bring Extension into the mainstream of development and dissemination of research results. Today, Extension is segregated from the new structures and mechanisms that are shaping the development of new technologies (15).

Finally, Federal Extensions's role in leading and coordinating the AR&E system and, in particular, the ability of Federal Extension to direct resources to national priorities, needs to be reevaluated. Changes will be needed in budgeting, planning, and evaluation if national goals and priorities are to be met, thus justifying continued expenditures of Federal resources. There is also concern that Federal Extension is not taking the lead in facilitating technology transfer between USDA agencies with research programs and state Cooperative Extension programs, or between states. Information must be made available and shared in a coordinated way to assure increased efficiency in technology transfer (15).

Extension has initiated joint appointments with other agencies. This concept is useful and could be extended, particularly with CSRS, ARS, and ERS where specific program areas need leadership in research and technology transfer. In addition, mechanisms for joint programming with other USDA and Federal agencies might be useful.

Structure Issues

To facilitate the structural changes needed for an effective AR&E system, a number of issues need to be addressed. Some of the issues are:

1. How can the integrity of separate agencies or research groups be retained while coordination of planning and other functions is improved? What alternatives exist?

2. What structure(s) will promote coordination of the various groups that contribute recommendations to S&E, e.g., Assistant Secretaries, industry groups, Crop Advisory Committees, CSRS, SAES, JC, UAB, ESCOP, ECOP, RICOP, NASULGC, NPS-ARS, BOA-NAS and others? Are all these groups needed? Does the structure foster excessive planning?

3. The structure seems to work well at the SAES-ARS level, and at the CSRS-SAES level, but ineffectively for example, at the more complex, CSRS-ARS-SAES levels and the Department level. Can the structure be changed in a way that will make it more effective at the higher or more complex organizational levels?

4. Much research of importance to agriculture is being carried out in institutions other than agricultural institutions. How

can the structure be modified to incorporate these institutions' expertise and contributions to agriculture?

5. What is the research and knowledge base of extension? How does this base relate to extension programs?

6. How can new sources of research and knowledge be developed and incorporated into public and private technology transfer programs?

7. How can the developing gap between research and extension be overcome? How can the obstacles posed by funding constraints and land-grant reward systems be mitigated?

8. How will training be provided to Extension professionals in biotechnologies, information technologies, applied research, and emerging technologies?

9. What should be the balance between top-down planning and decentralized programming?

10. What is the role of Federal Extension in setting priorities, planning, resource allocation, evaluation, and coordination of programs?

11. How can multidisciplinary approaches to programs be developed?

12. How should Extension programs be coordinated with other technology transfer programs in the public and private sectors?

13. What is the role of Extension in a plied research and commercialization of technologies? What structures are necessary to facilitate involvement?

FUNDING

Much has been written about the inadequate funding of the research and extension system especially at the Federal level (11, 17, 19, 20). Federal funding levels have been relatively stable for the past three decades especially to state agricultural experiment stations. States, for the most part, have made up the difference to the experiment stations. Federal appropriations are viewed as woefully inadequate by those who work in the system. However, those who control the appropriations process, i.e., OMB and Congress, are not compelled to increase Federal funding for AR&E. These groups point to agricultural surpluses, the budget deficit, and competing priorities (drugs, human health and diseases, environmental problems and social issues) as factors in their judgment against increased AR&E funding. A critical factor, in their opinion, is the system's inadequate justification for research dollars (7, 13. Only small increases in funding have been made in a few clearly defined areas such as groundwater quality and human nutrition. This situation is reflective of the problems discussed earlier encompassing mission, planning, priority setting, and structure. Until these issues are resolved, determining the adequacy of Federal funding is difficult.

An issue of growing importance is how to allocate funds in research and extension. Federal funds for research are distributed four ways: for intramural research conducted by USDA staff; in formula funds to the SAES'S; as grants for special R&D initiatives;

and as competitive grants. Federal funds for extension are allocated in two ways: in formula funds to state cooperative extension agencies at land-grant institutions; and as grants for special initiatives designated by the Congress.

Intramural and formula funding have been the major mechanisms for allocating funds in research and extension since the system's inception. Research and extension activities that require a continuous effort over many years to obtain significant results are often accomplished through base (formula) funding. Grants for special initiatives designated by Congress have also been institutionalized.

Competitive grants are the newest mechanism for allocating resources in agricultural research. Grants are awarded on the basis of quality and technical merit as judged by experienced scientists serving on peer review panels.

Competitive granting is flexible and responsive to new and emerging high priority research areas. In contrast to research, no competitive grants program exists for extension. Some grants for special initiatives are awarded on a competitive basis but they are a small proportion of extension's Federal budget. Major reliance on a formula system gives cooperative extension the discretion over how funds will be used with or without reference to national priorities.

In recent years, the grant system has been expanded to place increased emphasis on basic research and to fund excellence wherever it is found. Federal agricultural research grant-funding authorization for fiscal 1989 is shown below (10).

	($ million)
Competitive grants	40
Special grants, national programs	18
Special problem grants	24
Total	82
Percent of total CSRS Funds	24%

The average agricultural research grant is for $40,000 over 2.5 years (11). A major expansion of peer-reviewed competitive grants (which now account for a small proportion of research funds) is advocated by some experts as a way of improving allocative efficiency. Indeed, competitive grant funding currently seems to be the only politically acceptable source of additional Federal research support for agriculture.

There is major disagreement over whether competitive grant or base (formula) funding provides the best use of limited Federal funds for agricultural research. The following review makes a strong if indirect case for combining these allocation strategies in private and public funding (16).

Arguments for Base Funding

1. Base funding has been highly successful and served the nation well. A large number of studies, many of them by disinterested analysts at Yale University and the University of Chicago, show typical rates of return of 50 percent on public investment (2, 14). Huffman and Evenson (1989) estimate the rate of return on public crop research investment to be 62 percent. Fox Evenson, and Ruttan (1987) show a rate of return of 180 percent on specific crop research and disciplinary biological crop research for the 1944-83 period. While no single study can be taken as definitive because of data shortcomings, overall the evidence is compelling. The payoff from public agricultural research and extension calls for increased investment.

2. Base funding of agricultural research by the Federal Government is a well-established and accepted historic social contract. Public research at land grant institutions is viewed as an important source of unbiased information that speeds adoption of technology by producers. Breaking the contract alienates political support not only for agricultural grant research but for all agricultural research.

3. Base funding avoids the massive overhead of the peer review system. A sizeable (estimates run to 50 percent) portion of research resources is spent writing proposals and reports and reviewing proposals. Much of this is done by peers who have high opportunity cost. Base funding also utilizes review and competition at the local level but reduces overhead by relying more on administrators who know local circumstances and problems. Peer review is indeed a useful part of grant and base funding but, used excessively, it detracts from useful output of research. Bonnen (1986) notes that "Short-term project-by-project grant proposals do not add up to coherent long-term research programs," and points to wasted creativity of "senior scientists who no longer have time for anything but developing grant proposals and managing a laboratory."

4. Grants do not provide the long-term funding continuity essential for the most productive use of research resources, especially in the case of basic research. As noted earlier, the average duration of competitive agricultural research grants is only 2.5 years.

5. Peer reviewed grants are not necessarily effective in funding pathbreaking basic research. Holt (1989) notes that "... early basic research efforts in agricultural biotechnology and agricultural applications of artificial intelligence were supported by formula funds before biotechnology and artificial intelligence became buzz words in basic science circle s." Pathbreaking basic research resulting in antibiotics and the transistor were not recognized early on as important by peers. These and other breakthroughs did not arise from a peer reviewed grant proposal specifically addressing those goals. The peer review system is useful for directing substantial research resources to an area after the important basic breakthroughs have been achieved by base funding of private or public research. The most successful research establishments, including some land grant and ivy league universities, as well as Bell and DuPont laboratories, have huge endowments or other assured funding bases.

6. The large number of commodities, agroecosystems, and local social needs requires research capabilities in many locations. Base funding provides for this, whereas the peer review system might concentrate research funds on a few large centers. The profit motive might focus research on a few major commodities. Those who review grant funds may not be aware of local agroecosystems and their research needs. Research has been underway for some years on integrated pest management and conservation systems at land-grant universities. That research would have been delayed by peer reviewed allocations; it was called for by environmental and food safety lobbies along with some farmers rather than peer scientists.

7. The Federal Government has not dictated precisely how base funds should be spent by states. Some advocate a large Federal role in funding along with dictation of how funds are to be spent to best serve national priorities.

8. The strong complementary relationship between basic and applied research has contributed to the favorable record of agricultural research. Grant funding to institutions outside the system without departments of agronomy and animal sciences would not foster or benefit from this symbiosis.

9. Basic research funded by competitive grants tends to drive out applied research funded by base allocations because institutions direct resources to where additional funds can be obtained. Partly for that reason Holt (1989) contends that "the publicly-supported development and

adaptive research and extension components of the AR&E system are weak and getting weaker...”

Arguments for Competitive Grant Funding

1. Base funding is the product of historical political considerations and is not necessarily an efficient use of scarce funds in this period of budget stringency. It is especially influenced by commercial farming interests at the state level. The political process calls for applied research on immediate problems. Essential long-term basic research has low priority and is underfunded by a base system.

2. Base funding has not recognized that a critical mass of research resources is required for excellence. It spreads scarce resources too thinly.

3. Market incentives are essential to productivity as apparent from the worldwide success of market economies and failure of planned economies. Although basic research cannot be allocated by the market, the competitive grant is the best and closest alternative.

4. The academic tenure system limits the extent to which resources can be redirected in base funded institutions. Peer review enhances funding flexibility.

5. The National Institutes of Health, National Science Foundation, and other major sources of promising new biotechnology, provide mostly peer reviewed competitive grant funding.

6. Competitive grants reward research excellence wherever it maybe found, inside or outside the traditional agricultural research establishments. Fears of the agricultural establishment that competitive grants would place USDA agricultural research funds outside the USDA-land grant-SAES system are not well founded. The agricultural establishment received 77 percent of USDA competitive grants and 78 percent of grant funds in FY88.

Performing organization	Grants awarded	Amount ($)
Land grant -1862	98	10,282,180
SAESs	169	19,159,343
USDA/S&E Lab.		1.831.000
Subtotal	18	31,272,523
	(77%)	(78%)
Other public	32	3,208,200
Univ./College	28	3,487,287
Other	27	2,200,646
Total	372	40,168,656

SOURCE: Data provided b Competitive Research Grants Programs Cooperative State Research Service, U. S.Departrnent of Agriculture.

Funding Issues

To effectively address the concerns regarding funding for the AR&E system a number of questions need to be answered. They include the following:

1. What is the appropriate balance between base funds and competitive grants?

2. What is the appropriate balance between Federal and state funding for research and extension?

3. Should states have more responsibility to fund their infrastructure for conducting re-

search and extension focusing on local and state priorities, and use Federal funds for emerging national issues?

4. Is there a role for competitive grants in cooperative extension?

5. Has the redirection option for funding new priority research needs been adequately considered and used? Are incentives needed to encourage redirection?

6. How relevant is the current Federal formula for allocating resources?