Agricultural Research and Technology Transfer Policies for the 1990s

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A Special Report of OTA's Assessment on Emerging Agricultural Technology: Issues for the 1990s

CONGRESS OF THE UNITED STATES
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Foreword

Agricultural research and technology transfer policy will be a major subject of debate in the 1990 Farm Bill. The debate will likely focus on the level and type of Federal appropriations for and the planning and control of agricultural research and extension. This report addresses the central issues in that debate. It was requested as part of a larger study examining emerging agricultural technologies and related issues for the 1990s by the Senate Committee on Agriculture, Nutrition, and Forestry and the House Committee on Agriculture.

Although the study will not be completed until later this year, some findings from the study, provided in this report, are relevant to specific legislation regarding agricultural research and technology transfer that will be debated and acted upon in Congress.

In the course of preparing this report, OTA drew on the experience of many individuals. In particular, we appreciate the efforts of the project's consultants and contractors and the assistance of all the workshop participants who spent two days in September discussing issues and policy alternatives. We would also like to acknowledge the help of the numerous reviewers who helped ensure the accuracy of our analysis. It should be understood, however, that OTA assumes full responsibility for the content of this report.

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Chapter 1

Summary

A new agenda is emerging for American agriculture in the 1990s, and there are serious questions as to whether the current agricultural research and extension system can respond effectively. Agriculture is changing in at least two distinct ways. First, agricultural research is broadening beyond its traditional focus on increasing production, and more recently on competitiveness, to also address issues of food safety and environmental quality. Technology to increase production in the future will be developed with increased attention to food safety and the environment.

Second, agriculture is entering a new technological era – the biotechnology and information technology era – that holds great promise for enhancing productivity, producing a safe food supply, and sustaining the environment.

Concern is growing that the traditional agricultural research and extension (AR&E) system, if unchanged, maybe bypassed by the broadening research base and emerging technologies. Already one-third or more of Federal funding of agricultural research is granted by Federal agencies outside the United States Department of Agriculture (USDA) and non-USDA funding for research is expected to increase significantly.

Ten of the 57 state agricultural experiment stations received 75 percent of the Federal funds for biotechnology research from agencies other than USDA. It is noteworthy that these 10 experiment stations are those that have basic science departments within the associated colleges of Agriculture. Unimportant prerequisite for researchers in biotechnology is training in basic fields that underpin this technology (e.g., cellular physiology, biochemistry, genetics). These disciplines are generally lacking in colleges of Agriculture. Approximately 40 percent of the Ph.D. 's currently working in agricultural research did not graduate from a college of Agriculture.

All this implies that a broader base for agricultural research and its funding is evolving. But the research and technology transfer system is not well structured or coordinated and this could lead to serious problems. Without a close working relationship between basic and applied researchers on U.S. campuses and in Federal agencies, the lag time between the publication of basic scientific work and its adaptation into new technology will increase, damaging U.S. competitiveness.

There is the additional risk that without strong links between researchers and practitioners, basic researchers might focus on problems irrelevant to agriculture's needs or develop inappropriate approaches to perceived problems of agriculture. Faculty in fundamental sciences may not select problems meaningful to agriculture or design experiments that lead to readily adaptable solutions.

Ultimately, the private sector could surpass a weak AR&E system. A strong, mission-oriented AR&E system is needed to provide methods, products, and technologies to solve key agricultural problems. The United States cannot afford to have a public sector AR&E system falling behind the private sector and relegated to a role of simply reacting to, reviewing, or second guessing private sector research.

ISSUE AREAS FOR THE RESEARCH AND EXTENSION SYSTEM

The new agricultural agenda demands renewed and creative efforts to keep the AR&E system an effective and viable one for

American agriculture. A review of the system points to concern in the following areas:

1. Mission: USDA lacks a statement of goals, action to achieve stated goals, and systems to evaluate results against desired outcomes. As a result, no succinct written statement of the mission or policies of the AR&E system, or of Science and Education seems to exist within USDA. Without missions or policies, organizations can only express vague plans and priorities. It is very difficult to express commitment to clientele in terms of programs.

2. Planning: Effective planning directs resources to priority programs, problems, and issues in a well-thought, orderly manner. Within Science and Education at USDA, there are no short- or long-term plans for coordinating the activities of SAES, ES, ARS, or NAL. Nor are there plans for coordinating Science and Education activities with those of other USDA agencies such as ERS, FS, or its regulatory agencies.

   A number of planning activities exist at state, multi-state, or regional levels, but they usually relate to program implementation. Sometimes plans are made by individual scientists or groups of scientists who have no authority over resources. Significant amounts of planning occur without necessary commitment of resources to set goals, implement plans, and measure progress.

3. Priority Setting: There is little specificity and clarity in stating priorities for the AR&E system. Within USDA no set Science and Education priorities exist. Individual S&E agencies have identified their own research and research-related priorities, and developed their own justifications without the benefit of close coordination among themselves.

   A number of advisory groups independently set priorities for the AR&E system. These include the Joint Council on Food and Agricultural Sciences, the National Agricultural Research and Extension Users Advisory Board, the Experiment Station Committee on Policy, the Resident Instruction Committee on Policy, the International Committee on Policy, and the Extension Committee on Policy. However, there is no mechanism for reaching overall consensus. Stated needs for research and extension funding and for renovating facilities or replacing equipment are not prioritized.

4. Structure: Structure should facilitate the carrying out of mission, planning, and priority setting of the AR&E system. The present decentralized system is composed of Federal, state, and local partners. As research and extension budgets have declined, there has been increasing competition and division both within S&E at USDA and within universities. Little cooperation exists between many colleges of Agriculture and other colleges such as Arts and Sciences within the same university. In addition, new structures are evolving outside the traditional AR&E system as new technology is developed and transferred to the private sector for use. Extension's knowledge base, which has traditionally been drawn from the state experiment stations, has not kept pace with today's scientific advances. Extension runs the risk of being left out of the research and problem applications loop in the future.

5. **Funding:** There is evidence that the AR&E system is inadequately funded. Congress, however, will not increase fund-

ing as long as it considers the system's justification for additional funds to be inadequate. Until problems of mission, planning, priority setting, and structure are resolved, determining the adequacy of Federal funding will be difficult.

ALTERNATIVE POLICIES FOR RESEARCH AND TECHNOLOGY TRANSFER

OTA has identified a clear need for the AR&E system to have a well-articulated and coordinated research and technology transfer policy and proposes three alternatives:

- Status Quo Alternative: Continuation of the current policy as implemented under the 1985 farm bill.
- National Research and Extension Policy Alternative: Development of a larger Federal role in planning to align more closely research to end-user needs, without necessarily anticipating large increases in aggregate funding levels.
- Competitive Grants Alternative: Substantially increase the level of competitive grants research while continuing current levels of formula funding and/or appropriated funding for research and extension.

Status Quo Alternative

Based on the findings in this report and those of previous OTA reports dealing with the AR&E system, the likely consequences of the Status Quo Alternative are:

1. The new era of biotechnology and information technology will likely bypass the traditional AR&E system. A minority of the land-grant universities will compete effectively as technological advances are made in this new era.
2. Without a clearly enunciated mission-oriented policy, the AR&E system will continue to lack direction.
3. Planning and priority setting will continue to be ineffective, with no assurance of follow-through on initiatives and/or recommendations of the Joint Council and/or Users Advisory Board.
4. The AR&E system will continue to be rigidly structured and resistant to change.
5. Increased emphasis by land-grant universities and USDA on basic research, combined with accelerated technical change and continued neglect of applied research needs, will continue to widen the knowledge gap between research and extension.

National Research and Extension Policy Alternative

The National Research and Extension Policy Alternative is a mission-oriented approach designed to increase the AR&E system's responsiveness to the needs of the food and agriculture system. The major components of this system include:

- A clearly enunciated mission-oriented AR&E policy.
- A restructured, integrated and coordinated AR&E planning system.
- A combination of formula and competitive grant funds consistent with the conclusions of the planning system.

AR&E Policy

The first, and perhaps the most important component of the National Research and Extension Policy Alternative is a statement of clearly enunciated policy supported by the Secretary of Agriculture. It will emphasize that:

- Research and extension will be integral to carrying out all aspects of agricultural, food, trade and rural policy.
- The research and extension functions of USDA will be operated according to a comprehensive and coordinated plan.
- These functions will be mission-oriented with significant user influence on the planning process as well as on the resulting research and education programs.
- The research and technology transfer functions will be carried out by those scientists/institutions deemed to be the most competent, capable and efficient in achieving mission-oriented objectives.

Research and Extension Policy Planning System

The proposed policy statement implies a user-oriented research and extension system that places increased emphasis on competitive grants in research and extension programs. The key operating components include:

. Users Advisory Council (UAC)

. Agricultural Science and Education Policy Board (ASEPB)

. Technical Panels

. Existing research and extension agencies

Federal research and extension planning activities would be operationally centered in ASEPB, even though the planning process itself would begin in the UAC, in keeping with the user- and mission-oriented basis of the system. Research and extension agencies at the Federal, state, and local levels would also have planning functions.

Users Advisory Council. UAC would be independent of USDA and its role would be expanded considerably beyond that of the current Users Advisory Board (UAB). Its primary functions would include:

- Identification of important research and technology transfer problems. (Same as UAB)
- Development of recommendations on goals and funding levels. (Expanded role)
- Coordination of industry support for agricultural research and extension at the Federal level. (Expanded role)
- Evaluation of results. (Expanded role)

UAC board members would be elected to represent, and would serve at the pleasure of: private agribusiness firms and associations; farmers and farm organizations; public interest groups; foundations; and government action agencies. Each major group could include specialized segments. For example, agribusiness might include a representative from suppliers of inputs, food processors, and exporters. The total membership on UAC probably should not exceed 25.

Agricultural Science and Education Policy Board. ASEPB would be the research and technology transfer planning center for USDA. It would be chaired by the Assistant Secretary for Science and Education and would include the following members who would be appointed by the Secretary of Agriculture, or other relevant agency head in the case of NIH and NSF:

- Administrator of each USDA research and technology transfer agency (ARS, CSRS, ERS, ES, FS, NAL)
- Assistant Secretary for Economics
- ESCOP chairman or designated representative (experiment station representative)
- ECOP chairman or designated representative (extension representative)

- RICOP chairman or designatedre representative (resident instruction representative)
- One 1890 university dean or designated representative
- AASCARR chairman or designated representative (nonland-grant representative)
- NIH director or designated representative
- NSF director or designated representative

ASEPB Functions. ASEPB would manage the Federal research and extension mission-oriented planning process, and oversee the allocation of grants for research and technology transfer functions. Specific functions include:

- Establishment of Goals
- Establishment of Priorities
- Maintenance of Intelligence System
- Creation of Technical Panels
- Assignment of Responsibility
- Evaluation of Results

AR&E Funding

Funding initiatives would come directly from ASEPB and from UAC. Since the Secretary would overtly adopt the ASEPB policy, he/she should be more inclined to support the recommendations of ASEPB within the Administration and the Congress.

Likely Consequences of the National Research and Extension Policy Alternative

- A basis would exist for effective AR&E planning in a mission-oriented context. In contrast to the present system, research funding would be allocated to programs, not agencies.

  The argument that too much planning already exists stems largely from the ineffectiveness of current planning and follow-through.
- The USDA would have an internally consistent AR&E policy. The Secreta~ of Agriculture would be directly involved in establishing and endorsing AR&E policy.
- Multidisciplinary research would likely grow. Increased integration of biological (CSRS, FS and ARS) and economic (ERS) research would occur through ASEPB, UAC and the technical panels.
- The use of formula funds and competitive grants would be more balanced.
- Potential would exist for increased concentration of research and extension at specific locales within the system. This is occurring now, but the process would likely accelerate under this alternative.
- A mechanism would exist through the UAC for increased and more effective user input into AR&E decisions.
- Potential would exist for increased financial support for the AR&E system with improved planning, priority setting, and balance between research and extension.

Competitive Grants Alternative

The Competitive Grants Alternative was developed by the Board on Agriculture of the National Research Council, National Academy of Sciences. This proposal recommends:

Establishing a $500 million agriculture, food, and environment competitive research grants program within USDA. It would encompass all science and technology relevant to research needs for agriculture, food, and environment, from basic biology to social sciences and public policy. Grants would be open to researchers in public and private universities and colleges, not-for-profit institutions, and research agencies of the state and Federal government. Major emphasis would be placed on fundamental and mission-linked multidisciplinary research. Mission-linked multidisciplinary funding would be designed to facilitate application of knowledge and the transfer of technology to the user through joint research-extension studies.

Other recommendations include:

- Provision of researchstrengtheninggrantsto institutions and individuals.
- An increase in the duration and size of grants.
- Continuation of present levels of formula funds and USDA agency support forresearch or extension.
- Maintaining the Joint Council and UAB structure and the overall planning process now in place.

Differences Between the Competitive Grants Alternative and the National Research and Extension Policy Alternative

The Competitive Grants Alternative would place less emphasis on planning than the National Research and Extension Policy Alternative, which would make planning the driving force of the AR&E system. The primary emphasis and driving force in the Competitive Grants Alternative is more money for research; it assumes that a lack of adequate research funding is the major problem with the AR&E system. Structural problems in implementing a mission-oriented research and extension program are instead highlighted under the National Research and Extension Policy Alternative. The Competitive Grants Alternative places virtually all of its emphasis on research. In short, it is a research proposal whereas the National Research and Extension Policy Alternative is a research and extension proposal.

Likely Consequences of the Competitive Grants Alternative

- More funds would be available to all public and private universities and government research agencies able to compete on a scientific basis. This would greatly accelerate agricultural research, rates of discovery and technological change without changing formula fund support.
- Potential for dealing with complex multidisciplinary problems would increase.
- While funds would be available for strengthening grants, this proposal would inevitably lead to increased concentration of research talent.
- The basic/applied research gap could be reduced. However, neglect of technology transfer as a target for grant funds would inevitably lead to a serious gap between research and extension.
- No changes would be made to improve the planning system or the linkage between planning and execution. Nothing assures that funds will be allocated to the UAB - and Joint Council-determined priorities.
- The drain of the best scientific talent away from extension would accelerate as more funds become available for research.

CONCLUSIONS

Three alternatives have been described and the likely consequences of instituting each identified. It will be difficult for the current AR&E system to be effective in meeting the challenges facing American agriculture in the 1990s. In this regard, either of the other two alternatives represents an improvement over the Status Quo Alternative.

Questions remain as to whether a responsive mission-oriented system could be achieved by major structural change as implied by the National Research and Extension Policy Alternative, by increased research funding as implied by the Competitive Grants Alternative, or by a combination of the two. It is clear that without increased appropriations, structural change of the type contemplated by the National Research and Extension Policy Alternative will be required to obtain a mission-oriented system.

Increased mission-orientation and responsiveness could be realized by combining structural change with more competitive grant money. Imbalances between research and extension could be remedied by opening up the competitive grants process to the development and implementation of innovative extension programs. And, it seems likely that these improvements could be accomplished with a less than $500 million increase in appropriations for competitive grants.

Chapter 2

Overview

The U.S. food and agricultural sector enters the decade of the 1990s facing many new problems and issues that will challenge the agricultural research and extension (AR&E) system. A major focus of the system has been to increase productivity on a continual basis. In the decade of the 90's productivity will continue to be a concern, but additional concerns for food safety and for the environment will become equally important.

Agricultural productivity gains are slowing throughout the world. The slowdown, however, is more pronounced in the United States than elsewhere (16). As the U.S. agricultural sector slips from global leadership, its role in strengthening the nation's economy could decline. At the same time, however, consumers domestically and abroad are increasingly concerned about the safety of the food supply, and demand is growing for more emphasis on producing a safe and nutritious food supply at relatively low cost.

There is also increasing concern that gains in agricultural productivity not come at the expense of the environment or of biological and genetic diversity. Contaminants from a variety of current agricultural practices negatively affect water quality; certain agricultural practices also contribute to the release of greenhouse gases, possibly changing global atmosphere.

Meeting the challenges posed by these broadening concerns will require an AR&E system with an effective national strategy. It will also require advances in science and technology of a scale and scope the system has not previously experienced.

Fortunately, the food and agricultural sector stands on the threshold of a new technological era – the biotechnology and information technology era. This represents the third major technological era of the century following the mechanical era (1920-1950) and the chemical era (1950-1985). Biotechnology (recombinant DNA, cell biology, genetic manipulation) and information technology (artificial intelligence, expert systems, computers, networks) hold great promise for solving problems in the food and agriculture sector.

A pressing question is whether the AR&E system is capable of capturing the potential these new technologies promise. The development of these promising technologies will require a different environment than that of previous technological eras. Agricultural scientists will need to thoroughly understand the basic science underlying the technology and the AR&E system will have to be flexible and adaptive.

This report focuses on two major challenges to the AR&E system: 1) a broadening of problems to solve and 2) the advent of new technologies for solving these problems. The report identifies the problems these challenges bring to the system and concludes with a set of alternatives for structuring a national agricultural research and technology transfer policy that will help the system meet the needs of the next decade.

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-l-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 circles." 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?

Chapter 4

Alternative Policies for Research and Technology Transfer

The main premise of this report is that a broadening of research problems and the beginning of a new era in technology will present serious challenges to the AR&E system. The preceding discussion regarding mission, planning, priority setting, structure, and funding indicates that the system may not be able to effectively respond to these challenges.

Agricultural research and technology transfer policy will once again be a major focus of debate in the 1990 Farm Bill as it has been in the past two farm bills. The debate will likely center on the level and type of Federal appropriations for, and the planning and control of agricultural research and extension.

The lack of increased real funds for agricultural research has received much attention, most recently in the National Research Council report *Investing in Research,* to be discussed later. However, until there is a well articulated and coordinated research and technology transfer policy, debate about allocating new funds to the system is premature.

Effective planning to develop goals, determine priorities, commit resources and measure progress within the AR&E system is also crucial. Many within and outside the system complain that too much planning already exists. Most planning efforts, however, are relatively ineffective. Planning is not easy in a research system involving five Federal agencies, 57 state experiment stations, 50 extension services, and about 3,000 county extension offices.

Complicating the issue is the combination of Federal and state funds for agricultural research, and of Federal, state and county funds for extension. Each sector claims a dominant role in the system.

An effective system of Federal planning should consider, above all, the views of those who ultimately use the products of research and technology transfer services. The results of a user-oriented Federal planning system should be consistent with user-oriented state and local planning efforts. They certainly should not be contrary to state and/or local interests.

Planning must identify an appropriate balance of formula funds and competitive grants for agricultural research and extension. Large competitive research grants may create a serious imbalance between research and extension. Interestingly, proposals for substantial increases in competitive grants funding relate almost entirely to research. In reality, there may be an equally pressing need for competitive grants to develop education programs and extension expertise in a time of rapidly changing technology (8).

OTA proposes three alternatives for a national agricultural research and technology transfer policy:

- Continuation of the current policy as implemented under the 1985 Farm Bill, referred to hereinafter as the "status quo."

- Development of a larger Federal role in planning to align more closely research and end-user needs, without necessarily engendering large increases in aggregate funding levels, referred to hereinafter as the "national research and extension policy alternative."

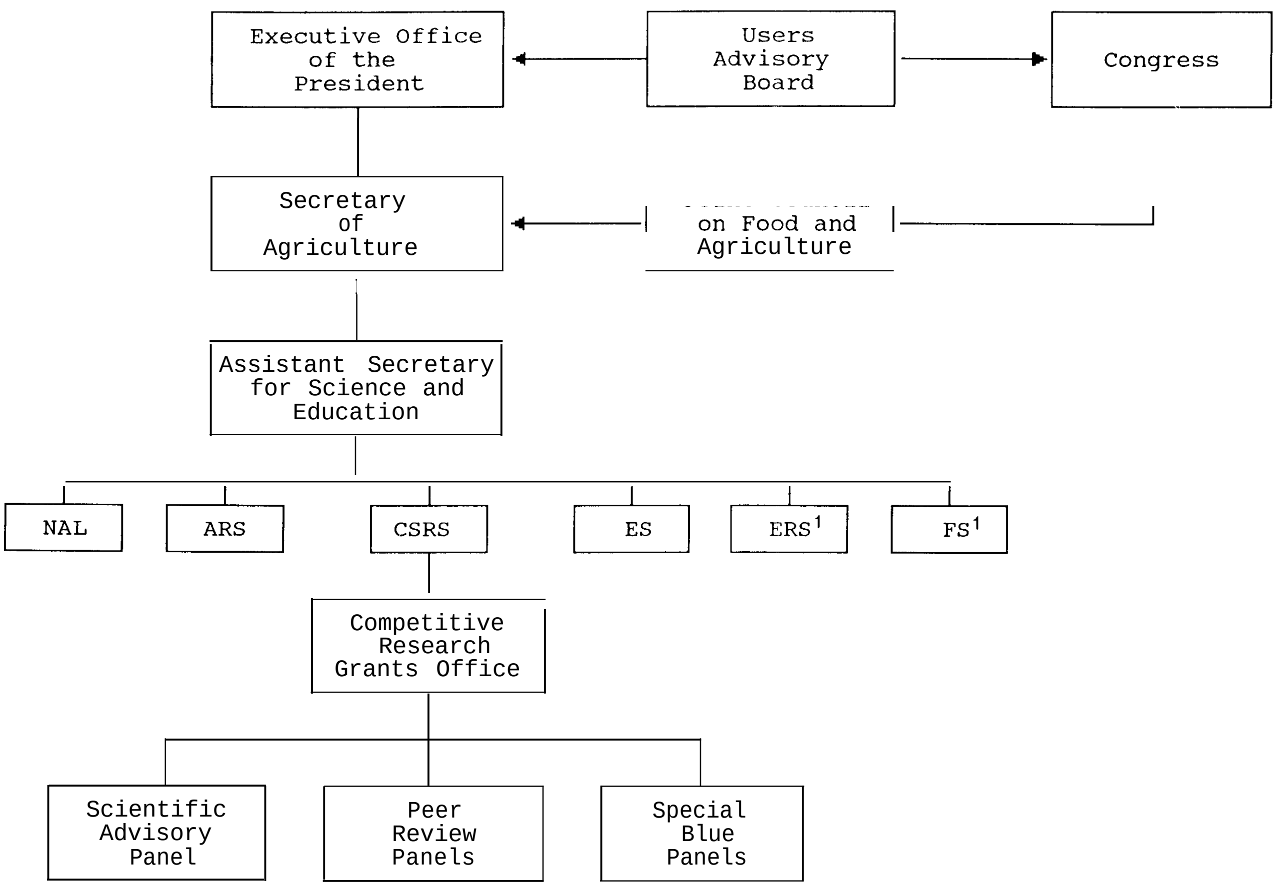
- Substantially increase the level of competitive grants research while continuing current levels of formula funding and/or appropriated funding for research and extension, referred to hereinafter as the "competitive grants alternative."

STATUS QUO ALTERNATIVE

A simplified schematic drawing of the current organizational structure of agricultural research and extension is shown in figure 4-1. While by statute the Users Advisory Board (UAB) reports to the White House, in practice it reports to USDA as does the Joint Council. It is difficult to depict accurately the complexities of the agricultural research and extension system in a single chart. Underlying virtually each component of the system is a series of national, regional, state, and local (extension) planning groups. For example, the Experiment Station Committee on Policy (ESCOP) reviews and establishes priorities as input into the Cooperative State Research Service (CSRS) budget process. Likewise, the Extension Committee on Policy (ECOP) reviews and establishes priorities as input to the Cooperative Extension Service budget process. An extensive six year planning function also occurs in the Agricultural Research Service (ARS) (8).

Based on the findings in this report and in previous OTA reports dealing with the AR&E system, maintaining the status quo will have the following consequences:

Figure 4-l-Current Organizational Structure for Agricultural Research and Extension



[1]ERS and FS report to separate and different assistant secretaries.

SOURCE: Office of Technology Assessment.

1. The new era of biotechnology and information technology will likely bypass the traditional AR&E system. Advances in these areas combined with changes in public policy regarding patent rights, have shifted the balance of agricultural research expertise in the direction of private sector firms and non-land-grant universities. A minority of the land-grant universities will remain competitive in this new era.

2. The lack of a clearly enunciated mission-oriented policy for the AR&E system means the system will continue to lack direction and focus.

3. Planning and priority setting within the system will continue to be ineffective. No mechanism exists to assure follow-through on initiatives or on recommendations of the Joint Council and/or Users Advisory Board. There is much planning but little resulting action.

4. The AR&E system will continue to be structured in a way that does not allow it to change easily.

5. Increased emphasis by land-grant universities and USDA on basic research, combined with accelerated technical change and continued neglect of applied research needs, will continue to expand the knowledge gap between research and extension. Extension has made an effort to improve its responsiveness to contemporary concerns through its national initiatives efforts. However, without commensurate shifts in the allocation of Federal funds to these specific initiatives, national impacts are difficult to detect and quantify. Extension continues to be "all things to all people" without specifically narrowing its priorities and allocating its resources to those priorities.

NATIONAL RESEARCH AND EXTENSION POLICY ALTERNATIVE

The National Research and Extension Policy Alternative is the product of OTA deliberations based on its analysis of the status quo. It is a mission-oriented approach designed to increase the responsiveness of the AR&E system to the needs of the food and agriculture system.

One principle problem with the current AR&E system is the lack of effective planning and its inability to respond to change. While the Congress has attempted to make the system more responsive through the formation of the Joint Council and UAB, the overall system resists change. The National Research and Extension Policy Alternative is designed to create a more responsive and better-coordinated AR&E system. The major components of this system include:

- A clearly enunciated mission-oriented AR&E policy.
- A restructured integrated and coordinated AR&E planning system.
- A combination of formula and competitive grant funding consistent with planning and political realities.

AR&E Policy

The first, and perhaps the most important component of the National Research and Extension Policy Alternative is a statement of clearly enunciated policy supported by the Secretary of Agriculture. While it can be argued that all secretaries of agriculture have supported the agricultural research and extension system – the original purpose for which the USDA was established – a policy statement of the type contemplated by this alternative has never been made. Such a statement could articulate the following principles to be implemented by all USDA- agencies:

- Research and extension will be integral to carrying out agricultural, food, trade and rural policy in all dimensions. Thus, every USDA action agency will be required to consider seriously its research needs when developing and implementing its programs. Likewise, USDA research and extension must be responsive to the research and technology transfer needs of the action agencies.

- The research and extension functions of USDA will be operated according to a plan. The broad outlines of this plan initially will be developed by an Agricultural Science and Education Policy Board (ASEPB) (discussed later). The plan will emphasize the Federal role in the agricultural research and extension system but leave room for state and local planning. More detailed planning will be expected within individual USDA research and extension agencies and at the state and local levels.

- The research and extension system will be mission-oriented with significant user influence on the planning process and on resulting research and education programs. (USDA and the land-grant system were created with a clear focus on mission-oriented problem solving.)

- Research and technology transfer functions will be carried out by the scientists/institutions most competent to efficiently achieve mission-oriented objectives. This implies no predetermined mix of competitive grants and formula funds. The optimum mix would be expected to change over time and be tuned to the specific nature of the problem. Action agencies may best be served by ARS or ERS funding, while certain types of mission-oriented basic research or the development of extension education materials may best be supported by competitive grants. This means relatively more emphasis on competitive grants for research and extension and less on predetermined formula funding.

Research and Extension Policy Planning System

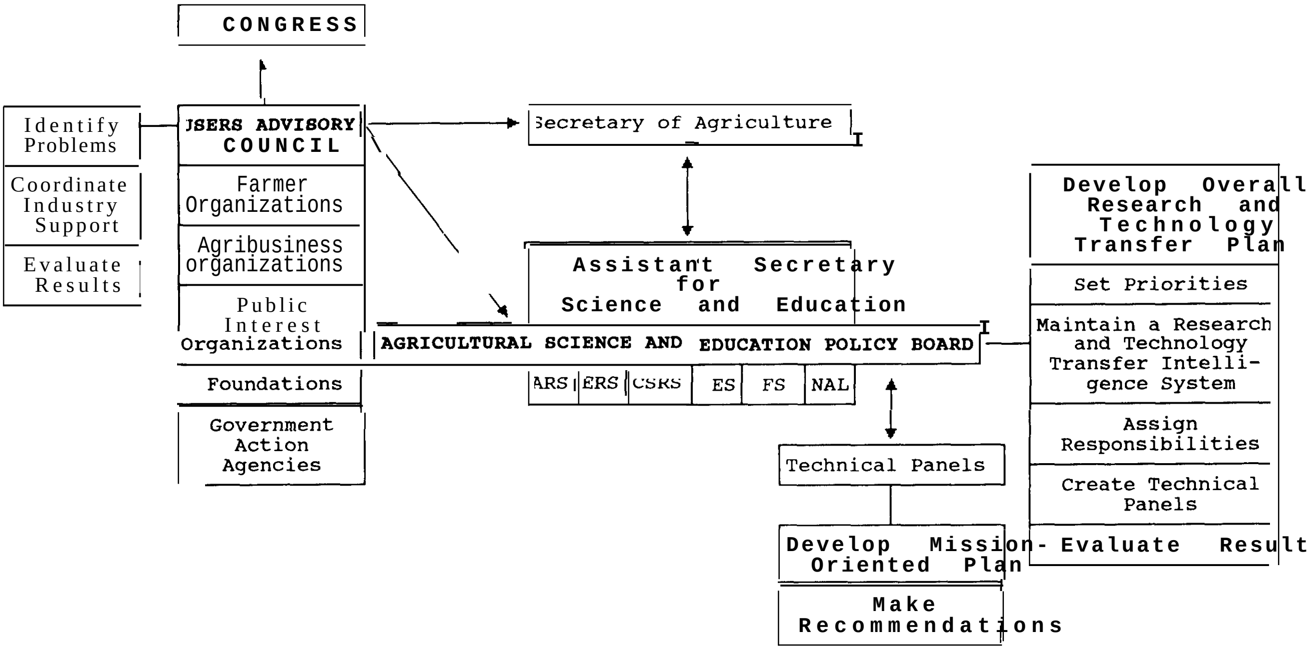
The proposed policy statement implies a user-oriented research and extension system that places increased emphasis on competitive grants in research and extension programs. The structure of the system is illustrated in figure4-2. The key planning components include:

- Users Advisory Council (UAC)
- Agricultural Science and Education Policy Board (ASEPB)
- Technical Panels
- Existing research and extension agencies
- Secretary of Agriculture
- Assistant Secretary for Science and Education (as ASEPB chair)

Federal research and extension planning activities would be operationally centered in ASEPB. However, the planning process itself begins in UAC, reflecting the user- and mission-oriented basis of the system. Planning functions are also included in research and extension agencies at the Federal, state and local levels.

Users Advisory Council. UAC input would be considerably expanded beyond that

Figure 4-2-Organizational Structure for National Research and Extension Policy Alternative



SOURCE: Office of Technology Assessment.

of the current Users Advisory Board (UAB). Its primary functions would include:

- Identification of important research and technology transfer problems.
- Development of recommendations on goals and funding levels.
- Coordination of industry support for agricultural research and extension at the Federal level.
- Evaluation of results.

The results of the UAC'S efforts would be reported regularly to ASEPB and annually to the Congress. UAC would be a quasi-public, quasi-private entity in that most of its active participants would be private organizations and foundations whose mission would be helping to plan public research. USDA action agencies or other interested public agencies would be involved in its deliberations.

UAC would be composed of board members representing:

. Farmers and farm organizations

- Agribusiness firms and associations
- Public interest groups
- Foundations
- USDA action agencies

In contrast to the UAB which is appointed by the Secretary, UAC board members would be elected to represent and would serve at the pleasure of the above groups.

Each group could include specialized segments. For example, agribusiness might include a representative from input supplies, food processors, and exporters. Farm groups might include commodity groups, general farm organizations, and cooperatives. It is suggested that the total membership on UAC not exceed 25.

Membership on UAC could be a part-time to full-time job. Members would be sought who have considerable scientific expertise and contact with clientele. UAC could be entirely a privately financed operation or it could be a joint public/private undertaking. It could operate much like producer checkoff programs with public accountability for its operations.

To participate in UAC on an active basis, some agricultural associations/action agencies would have to improve substantially their understanding of their research and technology transfer responsibilities. Each group would have to establish methods for deciding research and technology transfer priorities. The best organized member group would likely have the greatest influence on UAC decisions.

UAC would produce a set of recommendations regarding research goals and funding levels. In certain instances, joint public/private research undertakings may be recommended, and a commitment made for private funding support to tackle particularly complex problems. In addition to annual recommendations, UAC would produce interim reports as appropriate. UAC would interact with ASEPB on a continual basis.

Agricultural Science and Education Policy Board. ASEPB would be the research and technology transfer planning center for USDA. In contrast to the current Joint Council, it would have a single chair, the Assistant Secretary for Science and Education. It would include the following members who would be appointed by the Secretary of Agriculture, or other relevant agency head in the case of NIH and NSF:

- Assistant Secretary for Economics
- Administrator of each USDA research and technology transfer agency (ARS, ERS, CSRS, FS, ES, NAL)
- ESCOP chairman or designated representative (experiment station representative)
- ECOP chairman representative (extension representative
- RICOP chairman or designated representative (resident instruction representative)
- One 1890 university dean or designated representative
- AASCARR chairman or designated representative (non-land-grant-representative)
- NIH administrator or designated representative
- NSF administrator or designated representative

Experiment stations and extension services would be equally represented on

ASEPB. However, total scientific representation would be weighted toward research. NIH, NSF, and AASCARR representation is designed to secure increased coordination among the basic and applied research components as well as between the land-grant and non-land-grant components of the system.

Those ASEPB members who are not administrators of Federal agencies would serve for appointed or elected terms of no more than four years. All costs associated with ASEPB would be borne by USDA.

ASEPB Functions. ASEPB would manage the Federal research and extension mission-oriented planning process and oversee the allocation of competitive grants for research and technology transfer. In terms of specific functions, ASEPB would:

Produce a Rolling Five Year Agricultural Research and Extension Plan. This plan would set forth major goals, priorities, and means for achievement, and be transmitted to the Secretary of Agriculture annually for endorsement and to the Congress.

- *Establish Goals. The* plan, with input provided by UAC, would set forth specific, measurable goals for the system. For example, instead of merely identifying water quality as a problem, it would consider how to reduce nitrates in well water by 25 percent by 1993.

- *Establish Priorities.* The key to an effective planning system is the establishment of priorities within the overall budget constraints prescribed by the Administration and the Congress. UAC input would be an important component of the priority-setting process. The established priorities would have major impacts on funding allocations and competitive grant decisions.

- *Maintain Intelligence System.* To operate effectively, ASEPB would need to identify the major centers of research and technology transfer expertise. It would probably need to maintain a scientific talent data bank, which could be located in the National Agriculture Library.

- *Create Technical Panels. The* technical panels would develop general plans, approaches, and recommendations for tackling particular priority problems (see below).

- *Determine Responsibility.* ASEPB would need to determine which agency holds responsibility for tackling specific priority problems. Responsibilities may be delegated to particular agencies or combinations of agencies that would thereafter be accountable for funding and maintaining progress. The ultimate authority for designating responsibility would lie with the Assistant Secretary for Science and Education.

- Evaluate *Results.* Performance of the research and extension system in pursuing the goals set forth by the planning process would be assessed by ASEPB as a basis for future planning and funding.

To perform these functions effectively, ASEPB would require a staff to assist in planning and evaluation. Each agency might be asked initially to contribute staff with qualifications specified by ASEPB, although in the long run a combination of permanent and assigned staff may provide a desired mix of expertise.

In the ASEPB framework, the USDA research and extension agencies would continue to operate with the same general responsibilities they now have. However, their programs would be affected by decisions made in ASEPB. Through representation in

ASEPB, USDA would participate in making these decisions.

Technical Panels. Technical panels would be established by ASEPB for each major research and technology-transfer priority. These panels would contribute scientific input and expertise to the process of planning to complete missions and solve problems relevant to the priority.

Panels would be temporary although they might be reconvened to monitor progress on a particular priority and to develop additional recommendations. Panels would be of the minimum size required to include expertise on all dimensions of the mission, including its basic science, applied research, education, social and economic dimensions. Research and extension, as well as the private sector, would be represented.

Each technical panel would have four primary responsibilities:

- Define the dimensions of research and technology transfer encompassed by its mission.
- Delineate the alternatives and recommended research and technology transfer approaches for dealing with its mission.
- Describe the centers of expertise (public and private, land-grant and non-land-grant) relevant to its mission.
- Make recommendations regarding the appropriate overall level and mix of available funding. The technical panel would not make finding decisions nor would it be a substitute for peer review of funding proposals. Those responsibilities would continue to lie with the relevant agencies (ARS, ERS, CSRS, FS, ES). However, members of the panel might logically also serve on peer review panels.

Reports of technical panels would be transmitted directly to ASEPB to help guide its decisions regarding the research and extension plan.

Secretary of Agriculture. The role of the Secretary of Agriculture is to provide leadership and to convince the Administration of the importance of agricultural research and extension functions. The Secretary needs to support the planning process, the overall thrust of the plan, and its major priorities in pleading the case for funding within the Administration. And, the Secretary needs to establish policy regarding the cooperation of all affected Assistant Secretaries. Likewise, ASEPB and the related agencies need to be responsive to the priorities established by the overall political process within which policy and funding decisions are made.

AR&E Funding

Under the policy of the National Research and Extension Alternative, funding initiatives come directly from ASEPB and from UAC. The Secretary, having overtly adopted the ASEPB policy, would likely support ASEPB recommendations in negotiations with OMB.

UAC would be much more active in pressing the case for appropriations with the Administration and the Congress than the current UAB. Its effectiveness would be enhanced by the direct involvement of all major interest groups in research and extension decision processes.

This alternative would probably increase the relative importance of competitive-grant funding. More discretionary funds seem to be inherent to a system driven by effective user-oriented planning and by the goal of engaging the best scientists in research and technology transfer activities. Increased competitive-grant funds for research and extension, however, would not come at the expense of formula funds in this alternative. The appropriate mix of formula funds and competitive grants would nonetheless be determined by the deliberations of the technical panels, UAC, ASEPB, the Secretary, OMB and the Congress.

One of the most agonizing issues would be whether to continue Federal support for AR&E activities in every state. There is no easy answer to this and considerably greater study of this issue is required. A tradeoff between efficiency and the survival of specific state/local institutions could be involved. However, if serious attention is given to the missions, policies, and priorities on a national basis, each state would have an opportunity to establish its own role in the system.

Likely Consequences of National Research and Extension Policy Alternative

While all USDA research and extension agencies would remain intact, this alternative would change considerably the structure of research and extension, with attendant disruptive effects. These effects may be viewed positively or negatively, depending on one's perspective. However, if the current planning system is acknowledged to be flawed in light of changing conditions and if most of the following predicted consequences occur, then adoption of this policy alternative should have a positive impact overall.

Likely consequences are:

- The role of Federal planning in the AR&E system would increase. Increased emphasis on Federal planning would reduce the dominant role of state-oriented planning, and some responsiveness to local grassroots-expressed needs could decline. However, if the UAC and ASEPB are working properly, increased grassroots responsiveness could be anticipated at the Federal level.
- The USDA would have an internally consistent AR&E policy. The Secretary of Agriculture would be directly involved in establishing, monitoring, and endorsing AR&E policy. Thus, AR&E would have greater visibility within USDA than it now does.
- A basis would exist for effective, mission-oriented AR&E planning. Research funding would be allocated towards programs not agencies. The argument that too much planning already exists results largely from the ineffectiveness of current planning and follow-through.
- Multidisciplinary research would increase. Increased integrationof biological(CSRS, FS and ARS) and economic (ERS) research would occur through ASEPB, UAC and the technical panels. Extension considerations would also bean integral part of the planning process
- The use of formula funds and competitive grants would be more balanced.
- Certain research and extension functions could become more concentrated in the hands of agencies and/or institutions that have the greatest expertise. This process is gradually occurring under the status quo policies, but would likely accelerate. Some agricultural research and/or extension components may not be viable at some land-grant universities. Choices would need to be made as to where efforts (expertise) and resources are to be concentrated to secure Federal support that can be matched with state resources. Some institutions may decide not to seek Federal competitive grants for any of their programs. Some may discontinue certain agricultural

research and/or extension functions and/or contract for them with other states. Some functions could be performed on a regional basis by mutual consent of those institutions involved.

- A mechanism would exist through the UAC for more effective user input into AR&E decisions. This may lead to a more effective lobby on behalf of AR&E before the Congress and within the Administration. The technical panels and peer review of competitive grants would buffer this increased political clout and satisfy the need for objectivity in science.

- Potential would exist for increased financial support for the AR&E system with improved planning, priority setting, and integration of research and extension.

COMPETITIVE GRANTS ALTERNATIVE

The Competitive Grants Alternative was developed by the Board on Agriculture of the National Research Council, National Academy of Sciences in the report *Investing in Research*. This proposal recommends:

- Establishing a $500 million agriculture, food, and environment competitive research grants program within USDA to support national research initiatives in public and private universities and colleges, not-for-profit institutions, and research agencies of the state and Federal Government. The Competitive Grants Alternative would encompass all science and technology relevant to research needs for agriculture, food, and environment ranging from basic biology to the social sciences and public policy.

- Placing major emphasis on fundamental and mission-linked multidisciplinary research. Mission-linked multidisciplinary grants would be designed to facilitate application of knowledge and the transfer of technology to the user through joint research-extension studies.

- Providing research strengthening grants to institutions and individual.

- Increasing the duration and size of grants.

- Maintaining current levels of formula funds and USDA agency support for research or extension.

- No change in the Joint Council and UAB structure nor in the overall planning process.

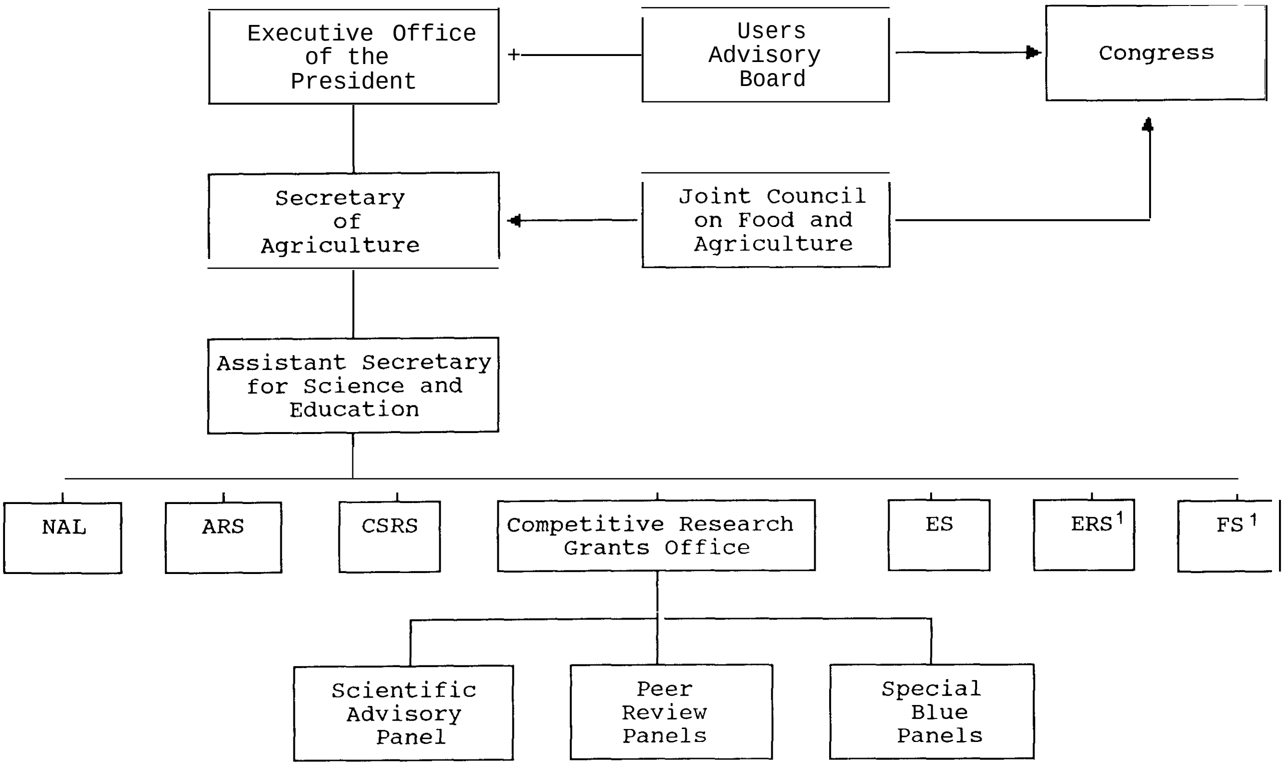
Competitive Grants Administrative Structure

The Competitive Grants Alternative recommends elevating the Competitive Research Grants Office from its current position in CSRS to agency status within USDA's Office of Science and Education. As such, it would have equal status with ARS, CSRS, ERS, FS, NAL and ES. Otherwise, the structure of USDA's science and education program would remain basically intact (figure 4-3).

Differences From National Research and Extension Policy Alternative

The Competitive Grants Alternative would not place as much emphasis on planning as the National Research and Extension Policy Alternative, which makes planning the driving force of the system. The driving force in the Competitive Grants Alternative is more money for research. Under the Competitive Grants Alternative, it is assumed that the major problem with the AR&E system is a lack of adequate

Figure 4-3-Organizational Structure for Competitive Grants Alternative



[1]ERS and FS would continue to report to separate and different assistant secretaries.

SOURCE: Office of Technology Assessment.

research funding, not structural problems in implementing a mission-oriented research and extension program as is assumed under the National Research and Extension Policy Alternative.

The Competitive Grants Alternative places virtually all of its emphasis upon research. One of its recommendations mentions technology and extension but only in terms of establishing a continuum from research to applications, not in terms of the development or delivery of extension programs. It maybe concluded that the Competitive Grants Alternative is a research proposal while the National Research and Extension Policy Alternative is a research and extension proposal.

Likely Consequences of the Competitive Grants Alternative

- Increased research funds would be available to all public and private universities (land-grant and non-land-grant) and government research agencies able to compete on a scientific basis. While formula fund support would not change, the role of competitive grants funding would be more comparable with what it is in NIH and NSE

- The rate of discovery and technological change in agricultural research would accelerate.

- Greater potential would exist for dealing with complex multidisciplinary problems.

- While funds would be available for strengthening grants, this proposal would inevitably lead to increased concentration of research talent However, this result may not be unique to this altemative. It has happened under the status quo and wouldprobably also happen under the research and extension policy alternative.

- The gap between basic and applied research could be reduced. However, neglect of extension education as a funding target would inevitably lead to a serious gap between research and extension.

- Nothing is done to improve the planning system and the linkage between planning and execution. There is nothing to assure that funds are allocated to UAB and Joint Council determined priorities.

- The drain of the best scientific talent away from extension would accelerate as more funds become available for research. And salaries would likely rise in research relative to extension. The best extension scientists would have strong incentives to seek experiment station appointments.

Appendixes

Appendix A.-Glossary of Acronyms

AASCARR	American Association of State Colleges of Agriculture and Renewable Resources
ARS	Agricultural Research Service
ASEPB	Agricultural Science and Education Policy Board
BOA	Board on Agriculture of the National Research Council
CSRS	Cooperative State Research Service
ECOP	Extension Committee on Policy
ERS	Economic Research Service
ES	Extension Service
ESCOP	Experiment Station Committee on Policy
FS	Forest Service
JC	Joint Council on Food and Agricultural Sciences
NAL	National Agriculture Library
NASULGC	National Association of State Universities and Land-Grant Colleges
NIH	National Institutes of Health
NPS	National Program Staff of Agricultural Research Service
NSF	National Science Foundation
OMB	Office of Management and Budget
RICOP	Resident Instruction Committee on Policy
SAES	State Agricultural Experiment Station
UAB	National Agricultural Research and Extension Users Advisory Board
UAC	Users Advisory Council

Appendix B.-Agricultural Research and Extension Funding Tables

Table B-1—Federal Expenditures by State for Agricultural, Forestry, and Veterinary Research and Development, As Reported by CRIS, FY86 (in dollars)

State	HATCH[a]	COMP[b]	SPGT[c]	Other CSRS[d]	Total CSRS[e]	CGCA[f]	Total USDA[g]	Other Federal[h]	Total Federal[i]	Percent of total from other Federal[j]
Alabama	3,242,000	115,000	06,000	475,000	4,037,000	199,000	4,236,000	326,000	4,562,000	7.1
Alaska	808,000	0	6,000	198,000	1,012,000	0	1,012,000	0	1,012,000	00.0
Arizona	1,565,000	399,000	29,000	260,000	2,353,000	404,000	2,757,000	1,399,000	4,156,000	33.7
Arkansas	2,789,000	233,000	03,000	444,000	3,769,000	583,000	4,352,000	259,000	4,611,000	5.6
Cali ornia	4,083,000	,191,000	85,000	803,000	8,261,000	1,541,000	9,802,000	13,984,000	23,786,000	58.8
Colorado	2,203,000	0	30,000	291,000	2,524,000	1,578,000	4,102,000	8,505,000	12,607,000	67.5
Connecticut	1,435,000	0	77,000	163,000	1,775,000	3,000	1,778,000	656,000	2,434,000	27.0
Delaware	1,048,000	46,000	28,000	90,000	1,212,000	53,000	1,265,000	145,000	1,410,000	10.3
D st. of Co umbia	472,000	0	0	0	472,000	0	472,000	0	472,000	00.0
F orida	2,341,000	722,000	1,249,000	339,000	4,651,000	1,705,000	6,356,000	2,976,000	9,332,000	31.9
Georgia	3,749,000	163,000	75,000	416,000	4,403,000	506,000	4,909,000	891,000	5,800,000	15.4
Hawaii	1,057,000	0	,652,000	104,000	2,813,000	222,000	3,035,000	2,834,000	5,869,000	48.3
daho	1,672,000	0	339,000	22,000	2,033,000	1,326,000	3,359,000	600,000	3,959,000	15.2
incis	4,359,000	229,000	68,000	257,000	5,014,000	1,828,000	6,842,000	2,269,000	9,111,000	24.9
ndiana	3,915,000	479,000	7 5,000	346,000	5,454,000	828,000	6,282,000	5,666,000	11,948,000	47.4
	4,6'	227,000	413,000	181,000	5,437,000	1,647,000	7,084,000	1,397,000	8,481,000	16.5
Kansas	2,763,000	404,000	290,000	282,000	3,739,000	564,000	4,303,000	3,756,000	8,059,000	46.6
Kentucky	3,979,000	0	0	346,000	4,325,000	0	4,325,000	0	4,325,000	00.0
Louisiana	2,594,000	43,000	226,000	333,000	3,194,000	215,000	3,409,000	574,000	3,983,000	14.4
Maine	1,474,000	268,000	92,000	370,000	2,204,000	236,000	2,440,000	928,000	3,368,000	27.6
Maryland	1,984,000	249,000	57,000	213,000	2,504,000	0	2,504,000	0	2,504,000	00.0
Massachusetts	1,790,000	268,000	28,000	162,000	2,247,000	560,000	2,807,000	151,000	2,958,000	5.1
Mich gar	3,993,000	711,000	,324,000	249,000	6,277,000	682,000	6,959,000	5,231,000	12,190,000	42.9
Minnesota	3,955,000	211,000	168,000	369,000	4,702,000	1,109,000	5,811,000	1,057,000	6,868,000	15.4
Miss ssipp	3,379,000	73,000	,303,000	438,000	5,192,000	918,000	6,110,000	648,000	6,758,000	9.6
Missouri	3,716,000	289,000	785,000	397,000	5,186,000	539,000	5,725,000	1,589,000	7,314,000	21.7
Montana	1,673,000	32,000	129,000	79,000	1,913,000	150,000	2,063,000	845,000	2,908,000	29.1
Nebraska	2,647,000	183,000	278,000	267,000	3,374,000	2,615,000	5,989,000	1,353,000	7,342,000	18.4
Nevada	980,000	116,000	18,000	87,000	1,202,000	67,000	1,269,000	351,000	1,620,000	21.7
New Hampsh re	1,152,000	0	5,000	192,000	1,349,000	0	1,349,000	0	1,349,000	00.0
New Jersey	2,168,000	68,000	,011,000	158,000	3,405,000	41,000	3,446,000	502,000	3,948,000	12.7

New Mexico	1,309,000	0	93,000	230,000	1,632,000	566,000	2,198,000	187,000	***2,385,000***	7.8
New York	4,435,000	861,000	748,000	143,000	6,187,000	1,175,000	7,362,000	11,587,000	***18,949,000***	61.1
North Carolina	5,289,000	756,000	392,000	484,000	6,921,000	1,867,000	8,788,000	7,043,000	***15,831,000***	44.5
North Dakota	1,917,000	32,000	218,000	118,000	2,285,000	272,000	2,557,000	402,000	***2,959,000***	13.6
Ohio	4,649,000	171,000	332,000	304,000	5,456,000	138,000	5,594,000	36,000	***5,630,000***	0.6
Oklahoma	2,480,000	139,000	276,000	330,000	3,226,000	163,000	3,389,000	334,000	***3,723,000***	9.0
Oregon	2,255,000	325,000	792,000	47,000	3,419,000	551,000	3,970,000	4,349,000	***8,319,000***	52.3
Pennsylvania	4,904,000	266,000	714,000	354,000	6,239,000	447,000	6,686,000	2,049,000	***8,735,000***	23.5
Puerto Rico	3,518,000	0	568,000	13,000	4,099,000	0	4,099,000	0	4,099,000	00.0
Rhode Island	1,003,000	0	34,000	67,000	1,104,000	0	1,104,000	207,000	1,311,000	15.8
South Carolina	2,790,000	0	583,000	22,000	3,394,000	0	3,394,000	34,000	3,428,000	1.0
South Dakota	1,956,000	0	0	181,000	2,137,000	0	2,137,000	0	2,137,000	00.0
Tennessee	3,845,000	51,000	226,000	334,000	4,456,000	83,000	4,539,000	301,000	4,840,000	6.2
Texas	5,138,000	281,000	480,000	532,000	6,431,000	2,176,000	8,607,000	4,987,000	13,594,000	36.7
Utah	1,424,000	164,000	146,000	185,000	1,919,000	452,000	2,371,000	1,745,000	4,116,000	42.4
Vermont	1,178,000	17,000	148,000	16,000	1,359,000	56,000	1,415,000	186,000	1,601,000	11.6
Virginia	3,387,000	2,000	119,000	432,000	3,940,000	1,168,000	5,108,000	3,368,000	8,476,000	39.7
Washington	2,909,000	55,000	327,000	329,000	3,620,000	713,000	4,333,000	2,789,000	7,122,000	39.2
West Virginia	2,171,000	0	46,000	272,000	2,489,000	163,000	2,652,000	65,000	2,717,000	2.4
Wisconsin	4,064,000	1,034,000	871,000	489,000	6,457,000	720,000	7,177,000	11,736,000	18,913,000	62.1
Wyoming	1,262,000	0	0	148,000	1,409,000	0	1,409,000	502,000	1,911,000	26.3
	139,485,000	11,873,000	19,502,000	13,361,000	184,212,000	30,829,000	215,041,000	110,799,000	***325,840,000***	34.0

[a]Hatch includes Hatch Funds and Regional Funds administered by CSRS.

[b]COMP are Competitive Research Grants administered by the Competitive Research Grants Office of CSRS.

[c]SPGT are Special Grants administered by CSRS.

[d]Other CSRS includes McIntire-Stennis Funds (Forestry), Evans-Allen Funds (1890 Colleges and Tuskegee institutes), and Animal Health Funds, (Veterinary Science) and any Other CSRS administered funds not included in HATCH, COMP, and SPGT.

[e]Total CSRS is the sum of HATCH, COMP, SPGT, and other CSRS.

[f]CGCA are grants, contracts and cooperative agreements administered by USDA agencies other than CSRS.

[g]Total USDA is the sum of total CSRS and CGCA.

[h]Other federal are grants, contracts, and cooperative agreements administered by federal agencies other than USDA.

[i]Total federal is the sum of total USDA and other federal.

[j]Percent of total from other federal is other federal divided by total federal multiplied by 100.

SOURCE: Compiled from Inventory of Agricultural Research, FY86, USDA/CSRS.

Table B-2—Federal Expenditures by State for Agricultural, Forestry, and Veterinary Research and Development, As Reported by CRIS, FY88 (in dollars)

State	HATCH[a]	COMP[b]	SPGT[c]	Other CSRS[d]	Total CSRS[e]	CGCA[f]	Total USDA[g]	Other Federal[h]	Total Federal[i]	Percent of total from other Federal[j]
Alabama	3,366,014	183,000	[illegible],381	3,331,309	6,981,704	982,000	7,963,704	897,000	8,860,704	10.1
Alaska	836,050	0	5,000	329,110	1,170,160	0	1,170,160	0	1,170,160	00.0
Arizona	1,637,354	875,000	373,145	314,729	3,200,228	[illegible],048,000	4,248,228	1,404,000	5,652,228	24.8
Arkansas	2,902,616	210,000	486,860	1,744,767	5,344,243	678,000	6,022,243	458,000	6,480,243	7.1
California	4,294,758	6,351,327	2,716,305	962,867	14,325,257	1,613,000	15,938,257	23,696,000	39,634,257	59.8
Colorado	2,259,405	605,000	243,61[illegible]	545,027	3,653,043	1,807,000	5,460,043	15,253,000	20,713,043	73.6
Connecticut	1,543,601	237,000	185,338	211,575	2,177,514	7,000	2,184,514	656,000	2,840,514	23.1
Delaware	1,089,885	0	0	574,783	1,664,668	1,000	1,665,668	114,000	1,779,668	6.4
Dist. of Columbia	476,964	110,709	0	0	587,673	0	587,673	0	587,673	00.0
Florida	2,447,831	945,988	,549,477	1,518,453	6,461,749	2,725,000	9,186,749	4,438,000	3,624,749	32.6
Georgia	3,954,450	1,535,775	1,453,202	2,177,963	9,121,390	834,000	9,955,390	1,642,000	11,597,390	14.2
Hawaii	1,099,005	30,000	2,559,929	140,837	3,829,771	486,000	4,315,771	2,239,000	6,554,771	34.2
Idaho	1,770,136	191,800	435,927	461,835	2,859,698	155,000	3,014,698	561,000	3,575,698	15.7
Illinois	4,584,251	2,059,207	2,749,860	406,121	9,799,439	2,074,000	11,873,439	2,093,000	13,966,439	15.0
Indiana	4,122,088	1,241,014	598,33	400,690	6,362,123	429,000	6,791,123	5,928,000	12,719, 23	46.6
Iowa	4,850,957	57[illegible],550	781,346	451,842	6,655,695	2,387,000	9,042,695	1,561,000	10,603,695	14.7
Kansas	2,842,448	947,000	3,183,009	316,593	7,289,050	342,000	7,631,050	3,537,000	11,268,050	32.3
Kentucky	4,166,166	444,760	513,830	2,106,843	7,231,599	0	7,231,599	0	7,231,599	00.0
Louisiana	2,696,202	305,000	645,357	1,641,717	5,288,276	303,000	5,591,276	374,000	5,965,276	6.3
Maine	1,536,176	74,130	158,916	542,482	2,311,704	252,000	2,563,704	544,000	3,107,704	17.5
Maryland	2,069,022	1,311,222	288,108	1,028,897	4,697,249	13,000	4,710,249	87,000	4,797,249	1.8
Massachusetts	1,866,247	1,861,368	934,133	262,554	4,924,302	134,000	5,058,302	382,000	5,440,302	7.0
Michigan	4,192,640	2,491,946	2,440,946	600,915	9,726,447	2,123,000	1,849,447	5,003,000	16,852,447	29.7
Minnesota	4,215,434	1,275,583	578,464	577,554	6,647,035	1,337,000	7,984,035	2,436,000	10,420,035	23.4
Mississippi	3,473,920	106,243	6,530,817	1,972,200	2,083,180	642,000	12,725,180	995,000	13,720,180	7.3
Missouri	3,909,750	978,900	833,134	2,041,592	7,763,376	523,000	8,286,376	1,948,000	10,234,376	19.0
Montana	1,753,480	100,000	189,962	422,224	2,465,666	739,000	3,204,666	2,286,000	5,490,666	41.6
Nebraska	2,783,752	294,300	1,519,989	301,524	4,899,565	2,412,000	7,311,565	1,442,000	8,753,565	16.5
Nevada	1,020,725	100,000	5,000	77,066	1,202,791	11,000	,213,791	441,000	1,654,791	26.6

New Hampshire	1,200,439	120,000	23,210	274,872	1,618,521	0	1,618,521	0	1,618,521	00.0
New Jersey	2,293,132	556,300	587,429	221,027	3,657,888	115,000	3,772,888	711,000	4,483,888	15.9
New Mexico	1,362,826	200,000	455,589	273,279	2,291,694	740,000	3,031,694	271,000	3,302,694	8.2
New York	4,608,443	3,093,150	995,083	736,146	9,432,822	1,815,000	11,247,822	16,903,000	28,150,822	60.0
North Carolina	5,505,386	1,863,736	423,597	2,765,458	10,558,177	2,806,000	13,364,177	6,220,000	19,584,177	31.8
North Dakota	2,006,894	100,000	2,976,733	145,970	5,229,597	465,000	5,694,597	561,000	6,255,597	9.0
Ohio	4,887,374	594,200	832,344	443,383	6,757,301	143,000	6,900,301	1,934,000	8,834,301	21.9
Oklahoma	2,591,197	776,261	895,693	1,447,560	5,710,711	204,000	5,914,711	874,000	6,788,711	12.9
Oregon	=,369,988	973,525	1,681,830	698,029	5,723,372	2,292,000	8,015,372	5,642,000	13,657,372	41.3
Pennsylvania	5, 26,469	1,177,225	1,079,531	573,481	7,956,706	1,225,000	9,181,706	4,989,000	14,170,706	35.2
Puerto Rico	3,608,987	0	403,643	12,508	4,025,138	0	4,025,138	0	4,025,138	00.0
Rhode Island	,040,549	262,450	15,000	88,851	1,406,850	0	1,406,850	263,000	1,669,850	15.7
South Carol na	2,893,497	108,602	577,153	1,624,812	5,204,064	155,000	5,359,064	113,000	5,472,064	2.1
South Dakota	2,050,865	97,700	50,811	202,441	2,401,817	146,000	2,547,817	36,000	2,583,817	1.4
Tennessee	4,050,782	1,017,000	236,940	2,039,361	7,344,083	50,000	7,394,083	286,000	7,680,083	3.7
exas	5,323,273	1,721,000	1,143,633	2,870,002	11,057,908	2,563,000	13,620,908	7,557,000	21,177,908	35.7
Utah	1,488,012	140,000	96,984	223,699	1,948,695	588,000	2,536,695	2,232,000	4,768,695	46.8
Vermont	1,230,703	0	0	292,003	1,522,706	373,000	1,895,706	346,000	2,241,706	15.4
Virginia	3,531,368	1,118,501	1,302,872	1,950,777	7,903,518	1,272,000	9,175,518	4,039,000	13,214,518	30.6
Washington	2,983,371	1,070,263	2,515,298	732,939	7,301,871	1,814,000	9,115,871	4,507,000	13,622,871	33.1
West Virginia	2,258,004	0	83,128	376,053	2,717,185	129,000	2,846,185	133,000	2,979,185	4.5
Wisconsin	720	2,486,231	224,981	613,205	7,534,137	751,000	8,285,137	13,384,000	21,669,137	61.8
Wyoming	1,305,636	98,690	5,000	198,132	1,607,458	0	1,607,458	625,000	2,232,458	28.0
	145,688,242	43,012,656	48,667,859	44,268,057	28' ,636,814	41,703,000	323,339,814	152,141,000	475,480,814	32.4

[a]HATCH includes Hatch Act Funds administered by CSRS.

[b]COMP are Competitive Research Grants administered by the Competitive Research Grants Office of CSRS.

[c]SPGT are Special Grants administered by CSRS.

[d]Other CSRS includes McIntire-Stennis Funds (Forestry), Evans-Allen Funds (1890 Colleges and Tuskegee Institutes), Animal Health Funds (Veterinary Science), and any other CSRS administered funds not included in HATCH, COMP, and SPGT.

[e]Total CSRS is the sum of HATCH, COMP, SPGT, and OTHER CSRS.

[f]CGCA are grants, contracts and cooperative agreements administered by USDA agencies other than CSRS.

[g]Total USDA is the sum of total CSRS and CGCA.

[h]Other federal are gra contracts and oope agreements administered by federal other than USDA.

[i]Total federal is the sum of total USDA and other federal.

[j]Percent of total from other federal is other federal divided by total federal multiplied by 100.

SOURCE: Compiled from *Inventory of Agricultural Research, FY88,* USDA/CSRS.

Table B-3—Top 10 State Agricultural Experiment Stations with Biotechnology Funds from Federal Sources Other than the U.S. Department of Agriculture for FY 1986 and FY 1988 (in dollars)

State	1986	1988
California	3,339,550	3,965,419
Colorado	519,316	1,387,628
Indiana	1,466,903	3,129,294
Michigan	1,580,824	993,944
New York	2,931,892	2,337,641
North Carolina	774,460	1,338,578
Texas	1,534,105	1,466,137
Utah	268,955	1,288,030
Washington	466,789	1,090,447
Wisconsin	3.232.370	3.240,762
Total for 10 SAES	16,115,164	20,237,880
Total SAES[a]	20,954,078	27,563,761
Proportion of 10 SAES To total (Percentage)	77	73

[a]Data was unavailable for the SAES from AL, AK CN, DE, DC, ID, NV, NM, ND, VT, and WY.

SOURCE: Compiled from *Emerging Biotechnologies in Agriculture: Issues and Policies, Progress Report VIII, Nov. 1989,* NASULGC.

Appendix C.-Workshop Participants

Agricultural Research and Technology Transfer Policy for the 1990s Workshop

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NOTE: Copies of this Special Report "Agricultural Research and Technology Transfer Policies for the 1990s: A Special Report of OTA's Assessment on Emerging Agricultural Technology Issues for the 1990s" can be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402-9325, GPO stock No. 052-003-01182-4.

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