THE NATIONAL ACADEMIES
Advisers to the Nation on Science, Engineering, and Medicine

FRONTIERS IN AGRICULTURAL RESEARCH

FOOD, HEALTH, ENVIRONMENT, AND COMMUNITIES

Globalization, trade liberalization, consumer preferences, public concern about food safety and the environment, and changes in the relationship between agriculture and rural communities have altered the context in which agricultural research is conducted. At the same time, emerging approaches in biotechnology and genomics, ecosystem science, and social science have also transformed the practices and products of agriculture. Advances in science have opened new frontiers in agricultural research that have put solutions to global challenges within our reach.

The US Department of Agriculture (USDA) is uniquely positioned to carry out research in these exciting new frontiers. The USDA's Research, Education, and Economics (REE) mission area is the main engine of publicly funded agricultural research in the United States. It funds and guides roughly $2 billion in federal research annually. REE's mission, carried out through four agencies—the Agricultural Research Service (ARS), Cooperative State Research, Education, and Extension Service (CSREES), the Economic Research Service (ERS) and the National Agricultural Statistics Service (NASS)—is to create a safe, sustainable, competitive US food and fiber system and strong, healthy communities, families, and youth through integrated research, extension, and education.

In response to a congressional mandate and at the request of the USDA, the National Academies convened a committee to review REE research, education, and extension and provide recommendations for future opportunities and directions.

New Vision for a Changing Landscape

Over the last century, productivity has been a major focus of agricultural research. Driven by advances in plant and animal genetics, nutrition, and health, this research has paid off with major productivity gains, such as the tripling of corn yields over the last 50 years. Today, worldwide changes have shifted agriculture's focus beyond food and fiber production toward goals of improving public health, social well-being, and the environment. Agriculture is playing a new and different role in delivering nutritional, pharmaceutical, and bio-based products; in providing sound stewardship of resources; and in supporting rural communities.

The changing social and scientific context of agriculture requires a new vision of agricultural research—one that will support agriculture as a positive economic, social, and environmental force and that will help the sector to fulfill ever-evolving demands with USDA's REE agencies leading the way. Table 1 (page 3) provides a sample of research opportunities that support the new vision.

To fulfill this vision, REE must be more anticipatory and strategic in its use of limited resources and must guide and champion new directions in research. There is a need for high-level leadership in food and agricultural research to create a long-term coherent vision for REE research, to promote interagency

Box 1. Factors Altering the Context of Agriculture

Changing consumer demands require a wider variety of products with increasing health and environmental benefits.

Shifting market structures coincide with decreased economic importance of agriculture in rural areas.

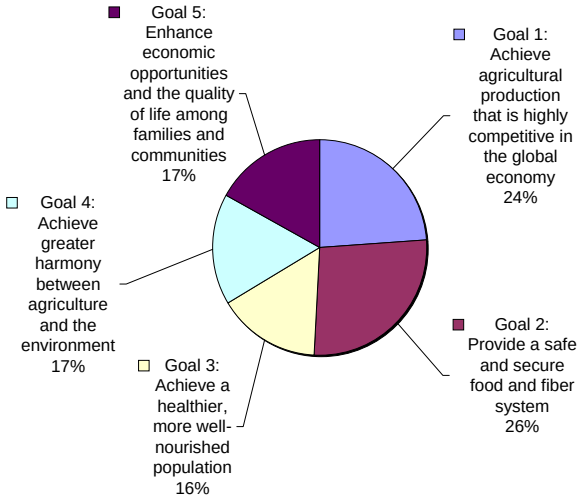
New scientific advances, such as genomics and proteomics, greater understanding of ecosystem patterns and processes, and new modeling tools have altered the practices and products of agriculture and provided further opportunities for research.

Expanded private-sector research focused on productivity gains heightens the need for public research with broad social benefit.

coordination, to broker partnerships outside the REE agencies, and to integrate REE research within the federal research program. REE needs to build capacity by hiring more scientists in research fields that have the greatest opportunities to address societal goals, including integrative environmental science, ecology, economics, and sociology; human genetics and bioinformatics; and human nutrition, public health, and food safety.

Focusing REE Efforts Toward New Opportunities

Many forces help shape federal priorities and resource allocation for agricultural research and education. Congressional authorization and appropriation lays the foundation for focus and funding. USDA and the REE agencies develop goals and objectives in periodic strategic planning and performance reporting.



A review of the REE 5-year strategic and performance plans yields a mixed picture of how well the agencies are positioned to respond to this report's vision for agricultural research. Figure 1 shows the distribution of REE funds for five strategic research goals according to agency performance plans. In the committee's view, the current strategic plan and resource allocation do not adequately address the new opportunities for agricultural research. Half the current REE resources are devoted to traditional agricultural productivity (goals 1 and 2), with the remainder allocated among human health, the environment, and communities.

Like any relatively large organization, the REE agencies function in an increasingly volatile, complex environment. A traditional organizational structure challenges REE's ability to respond to new pressures and interests. How can REE develop the kind of enterprise required to support agricultural research, balancing the continued need for productivity gains with emerging demands? To have the greatest impact, REE resources, always limited, should be targeted at efforts in which they can make a unique, critical, and high-impact contribution to the public good. Expansion into these more strategic research fields will require a focus in the following areas of research management.

Box 2. Agricultural Research Funding Facts

Federal nondefense expenditures have grown faster for health research and basic research than for agricultural research. From 1976 to 2001, USDA research expenditures increased by 24%, NIH research expenditures increased by 157%, and NSF research expenditures increased by 46%.

Private-sector expenditures for agricultural research now exceed public-sector expenditures.

The USDA share of federal nondefense expenditures peaked in 1986 at 5.7% but has since declined, reaching its lowest point in 16 years in 2001 (4.8%). The USDA share of funding that supports state agricultural experiment stations (SAESs) is declining.

Clearer priority-setting mechanisms. The REE agencies' short- or long-term planning does not appear to include an important role for coordination with other research institutions or for strategic positioning. There is little evidence that the agencies explicitly set priorities according to where their research investments might play a unique or critical role. The report recommends that REE priorities be informed by a clear articulation of the major national priorities for public research, extension, and education. Furthermore, development of a system for anticipating, reporting on, and identifying strategies to address emerging research needs is necessary for such prioritization. The report finds that REE priorities would be strengthened if planning activities were more integrated, aligned, and collaborative among agencies.

More flexibility in funding and shifting research agendas. The four current funding mechanisms in agricultural research are formula funding, competitive grants, special grants or congressional

earmarks, and intramural research. The diversity of financial sources usually ensures that local, state, regional, and national agricultural research needs are addressed, and evidence suggests that such diversity has been a historical strength of the USDA research system.

In the future, REE will need greater flexibility to respond most effectively to new research opportunities and to meet the needs of USDA program agencies. System flexibility can be enhanced by increasing the proportion of funds in competitive grants and cooperative agreements, which would also help to ensure that the best talent addresses new and emerging issues. The report recommends increasing total competitive grants to 20–30% of the research portfolio and dedicating a higher percentage of funds to cooperative agreements.

Greater accountability to stakeholders. With a new, broader mandate, agricultural research should be accountable to a wider client base. Traditional REE stakeholders—producers, processors, and commodity groups—have been joined by nutraceutical producers; sustainable-, alternative-, and organic-farming interests; public and private natural-resource and land managers; conservationists; and rural communities and government agencies.

Table 1. Research Opportunities and Key Examples

Globalization
Evaluate impact of globalization on US agriculture and research priorities. Predict how global macroeconomic policies, policy distortions, and changes in research policy will shape incentives in US agriculture.
Improve agricultural productivity and product quality while optimizing resource use. Develop precision-agricultural techniques and decision-support tools that will reduce externalities from agricultural production.
Evaluate the economic, social, health, and environmental effect of agricultural practices. Assess risks, benefits, and ethical implications of new technologies.
Emerging Pathogens and Hazards in the Food Chain
Reduce the risk of bioterrorism. Identify key points to avert biologic attack on food and water.
Improve microbiologic food safety. Understand the epidemiology and control of microbial pathogens.
Minimize hazards of food allergens/toxicants. Understand and predict modes of action of allergens/toxicants.
Manage plant and animal diseases. Enhance disease resistance.
Nutrition and Human Health
Advance research on bioactive food compounds. Identify and understand modes of action for most promising compounds to address major public health threats.
Elucidate genetic mechanisms that affect human health and nutrition. Discover genetic basis for nutritional status and disease risk in order to design nutritional interventions.
Improve the nutrient content of foods. Modify fats in plant and animal products to reduce cardiovascular disease, cancer, and diabetes risk.
Improve understanding of food consumption behavior and its links to health. Discover behavioral determinants of dietary change in vulnerable subpopulations.
Environmental Stewardship
Reduce pollution and conserve natural resources. Evaluate impacts of agricultural chemicals and wastes at multiple geographic scales.
Advance environmentally sound alternatives. Develop pest-control alternatives and crops that use nutrients more efficiently.
Deliver new environmental benefits. Elucidate the science underpinning land-use management policies for reducing agricultural runoff, controlling carbon emissions, and conserving biologic diversity.
Integrate leading-edge environmental science concepts and techniques. Use advances in geospatial technology, molecular approaches, modeling, and social science to solve problems at a systems level.
Quality of Life in Rural Communities
Evaluate effects of changes in market structure. Understand how changing global markets affect vitality of the rural economy.
Meet the challenge of rural development in a changing context. Discover how policies can broaden and diversify the rural economic base.

Various studies have shown that stakeholder involvement can help to ensure the relevance and impact of agricultural research. REE currently uses many mechanisms for gathering stakeholder input, ranging from formal advisory boards to county meetings. These can tax stakeholder time and resources and stretch REE capacity and resources. Moreover, agencies find it increasingly difficult to reconcile stakeholders' competing views. The report recommends that REE conduct a national summit every 2–3 years that would engage the four REE agencies and a broad representation of stakeholders at the local, national, and regional levels. It would provide a forum for consistent feedback regarding the use of stakeholder input in agency planning.

REE should develop and adopt better mechanisms for measuring the long-term impacts of their research. More effective and user-friendly tracking systems will contribute to improved self-evaluation and reporting of progress to groups outside REE and the public. Electronic media are an increasingly critical and strategic means for communicating impacts and research results to the general public and should be a focal point for development and expansion.

Increased multidisciplinary research and collaboration. The increasing complexity of issues and challenges facing our food and fiber system, the environment, and families and communities requires disciplinary, multidisciplinary, and systems-level approaches. REE has engaged in a number of effective multidisciplinary efforts. For example, the 1990 National Water Quality Initiative coordinated the efforts of multiple disciplines to reduce agricultural watershed contamination through a 10-year joint venture of the four REE agencies, the Natural Resource Conservation Service with the US Department of the Interior, the US Geological Survey, the US Department of Commerce, and the US Environmental Protection Agency (EPA).

USDA should evaluate successful multidisciplinary structures—such as task forces, centers, institutes, and initiatives—in terms of their potential application in REE. Graduate education institutions should expand multidisciplinary education to include a broader understanding and appreciation of different scientific perspectives and better integration of those perspectives.

REE also has a strong history of collaborative partnerships with land-grant universities, other agencies of the federal government, and international organizations, a few examples of which are highlighted in Box 3. In addition, private-sector collaborative partnerships have emerged in the last 20 years that hold promise for engaging in the new research opportunities described in this report but also raise new questions about the distribution of benefits from research. REE should continue to build collaborative partnerships, especially with other federal agencies. REE should develop intellectual-property policy for agricultural research to best focus private–public efforts toward the public benefit.

Box 3. Examples of REE Collaborative Partnerships

ARS and the National Institutes of Health (NIH) have teamed on many projects, including the National Food and Nutrition Analyses Program and a 1998 Carotenoid Food Composition Database.

ERS worked with the National Science Foundation, EPA, and National Oceanic and Atmospheric Administration to coordinate extramural funding for support of climate-change research.

NASS has partnered with several international collaborators to assist developing and transitioning economies in survey and census design and data-collection activities.

CSREES and EPA collaborated on Healthy Indoor Air for America's Homes, a project linking EPA with Cooperative Extension in 46 states to eliminate household hazardous substances.

For More Information…Copies of *Frontiers in Agricultural Research: Food, Health, Environment and Community* are available for sale from the National Academies Press; call (800) 624-6242 or (202) 334-3313 (in the Washington metropolitan area), or visit the NAP home page at **www.nap.edu.** This report was produced under the auspices of the National Academies' Board on Agriculture and Natural Resources, www.national-academies.org/banr.

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