

DRAFT Plan: Research, Education, and Economics
February 22, 2011

Preamble

As the 21st century unfolds, America faces economic, social, and environmental challenges that require a strong and innovative system of agricultural science for answers. Agriculture and natural resources are at the crossroads of the world's most critical problems: establishing sustainable food production, providing clean and abundant water, responding to climate change, developing renewable energy, and improving human health. From fostering continued economic growth to mitigating the effects of climate change and addressing food security, the United States can continue to be a leader in global agriculture. Yet the challenges facing agriculture, natural resources, and conservation are immense, and need to be faced with a robust research enterprise and educational programs in order to out-innovate, out-educate, and out-build the rest of the world. Our continued global leadership and success depends upon a renewed and reinforced commitment to our world-class agricultural science and research capabilities, as well as training the next generation to carry these studies into the future. If we want to keep America at the forefront of global competition, we need to make smart investments in education and innovation, leveraging the diverse resources and talent we have, especially in the agricultural sciences. The education begins with supporting science, technology, engineering, and math (STEM) programs so that science and mathematics are woven seamlessly into students' skills and interests.

The framework for my role as Under Secretary for Research, Education, and Economics (REE) in this respect has been delineated by the 2008 Farm Bill and by "A Roadmap for USDA Science," produced by my predecessor in early 2010. During my tenure as Under Secretary, I have held a series of informal and formal consultations with multiple stakeholders in U.S. Department of Agriculture (USDA) science, including the National Agricultural Research, Extension, Education, and Economics (NAREEE) Advisory Board, to assess REE's progress in achieving the vision set forth in these documents. I have also reviewed the reports prepared by REE staff in 2009 in gathering background for the "Roadmap" that examined USDA science in the context of other science agencies in the Federal Government, looking for significant disparities in our programs. These sources, as well as lessons learned from implementation of Farm Bill provisions, especially related to the establishment of the National Institute of Food and Agriculture (NIFA), Agriculture and Food Research Initiative (AFRI), and the Office of the Chief Scientist, can significantly inform our planning going forward.

Through this systematic review process, I discovered several areas of concern regarding how the education and training of the next generation of scientists, and of the future of agriculture, are being addressed. The important work done by the National Agriculture Statistics Service (NASS) and the Economic Research Service (ERS), for example, could be made much more visible. We need to ensure the sustainability of our core programs and competencies in order for USDA science to be able to deliver on the strategic priorities of the Department. We also need an effective communications strategy to increase the visibility and relevance of USDA science—one that recognizes the full scope of USDA's science portfolio, including the four REE agencies, but also the important research program within the Forest Service. Ultimately, USDA

science needs an **action plan** to link USDA's broader strategic goals with the specific research agenda of REE, and then identify specific actions with measurable outcomes to help coordinate our efforts to achieve those goals.

Now more than ever, careful and strategic planning is fundamental to global prosperity and security, and a dynamic and integrated strategic vision can be a guiding force for continued innovation, as well as the means to maximize the potential of our world-renowned system of agricultural science and research. With this challenge at hand, as USDA's Chief Scientist and Under Secretary for REE, I am pleased to introduce USDA's 2011 science and research action plan. The year 2012 marks the 150th anniversary of the historic partnership between the States and the Federal Government that formed the basis for the land-grant university system, which, along with local extension offices and experiment stations, not only revolutionized American education and agriculture, but together transformed the Nation's economic and social fabric. In anticipation of this anniversary, and in light of the many pressing challenges we face, I believe it is now time to renew our Nation's commitment to maintaining and growing a progressive and innovative system of agricultural science. The time is right to reinvent and re-imagine a research and development partnership between the States and the Federal Government to face today's many challenges. And we need to craft a new compact with America—its States, its agricultural producers, its consumers, and its colleges and universities—to bring into existence a renewed agricultural enterprise capable of feeding the world and inventing new technologies and energy sources needed in the decades to come.

Our new compact must reflect that, collectively, we have—at USDA and with our university partners—a robust infrastructure to perform world-class science. But instead of building separate and duplicative resources agency by agency, State by State, university by university, we should identify which agencies, Departments, and institutions have the critical skills to solve a problem, and focus that combined knowledge and capacity where it will do the most good. Our new compact must reflect that we have at USDA, and in our partner institutions, many of the world's best scientists. This rich and deep talent base is capable of addressing almost any problem we can put before it. With the right vision, we can figure out how those many problems relate to our most urgent issues and tackle the root causes rather than manage the symptoms.

As Under Secretary for REE I intend to use the valuable resources in our agricultural research system to implement an efficient and effective strategy for the diverse stakeholders in the public and private sectors to collaborate on our common concerns in an inclusive and integrated manner. Having arrived at USDA 2 years into the Obama Administration, I believe it is time to pause and reflect on what has been accomplished, and take a fresh look ahead. With the 2008 Farm Bill now 3 years behind us, we need to also reflect on how well USDA has accomplished the research agenda it set forth, and redouble our efforts to successfully meet the strategic goals still before us. Looking forward, yet facing the realities of today's economic climate, we must now simultaneously streamline and enhance our research capabilities while using our resources intelligently and efficiently. This will mean integrating our diverse capabilities into a collaborative and cohesive operational unit that will be able to multiply our research yields, focus our vision, unify our voice, and enhance our chances of success. It also means laying the foundation for a strong economic future by attracting the next generation of

students into the field of agricultural sciences and research, to build a pipeline of talent that keeps America leading the world on agricultural innovation.

We have proven in the past, time and again, what American agricultural science and research is capable of, and it is once again time for us to renew our commitment to its strengths and possibilities. The immensity and diversity of the difficulties we face allow us an excellent opportunity to once again demonstrate our ability and capacity to rise and meet the greatest of challenges. There isn't a moment to lose if our country is going to out-innovate, out-educate, and out-build the rest of the world, and REE has a unique role in achieving these goals.

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I. Introduction

In June 2010, Secretary Thomas J. Vilsack released the *U.S. Department of Agriculture (USDA) Strategic Plan for 2010-2015*, which articulated a comprehensive agenda for USDA.

Fundamental to accomplishing this agenda is ensuring an equally comprehensive approach to science education and information to support subsequent action. Tasked by then Under Secretary Rajiv Shah, the Research, Education and Economics (REE) mission area developed “*A Roadmap for USDA Science*” in early 2010, which articulated a vision for delivering the research, tools, and statistical data needed to meet the needs of USDA agencies and the country. That vision also reflected the growing needs domestically and globally for a comprehensive approach to agriculture and working lands. In a world undergoing major economic challenges, it is not surprising that people turn to the basic provisioning factors of food, water, and shelter. USDA science is central to providing these basic requirements of life.

*“The ‘Roadmap’ presents an assertive and progressive approach to transforming USDA REE into a high-profile research organization.”
(NAREEE Advisory Board, December 2010)*

In “*A New Biology for the 21st Century*”¹ the National Academy of Sciences identified a set of challenges that integrate fundamental biological understanding with critical societal issues. One of the questions posed was “*how can Federal agencies more effectively leverage their investments in biological research and education to address complex problems across scales of analysis from basic to applied?*” In addition, the articulated principles of a New Biology emphasize integration—of disciplines and approaches—but perhaps most relevant to USDA is to **purposely** organize research around problem-solving. These can readily be viewed as principles of USDA science.

¹ A New Biology for the 21st Century. National Research Council. National Academies Press. 2009. Available at <http://www.nap.edu/catalog/12764.html>.

REE delivers the scientific discovery mission of USDA through:

The ***Agricultural Research Service (ARS)***, is the largest intramural research agency of USDA. ARS has a workforce of approximately 8,000 employees, including 2,200 life and physical scientists, engineers, and veterinarians who represent a wide range of disciplines and work at more than 100 locations across the country and at five overseas laboratories. The ARS research agenda is broad, with about 1,200 research projects organized under four major program areas: Nutrition, Food Safety, and Food Quality; Animal Production and Protection; Natural Resources and Sustainable Agricultural Systems; and Crop Production and Protection.

The ***National Institute of Food and Agriculture (NIFA)*** is USDA's primary extramural research, education, and extension funding agency. Its mission is to lead food and agricultural science to create a better future for the Nation and the world by funding research, education, and extension projects and programs, some of which are specific to the Land-Grant University System, and others open to participation by other partner organizations.

The ***Economic Research Service (ERS)*** is USDA's primary source of economic information and economic and social science research. ERS' mission is to anticipate economic and policy issues related to food, agriculture, the environment, and rural development, and conduct research that informs public program and policy decisions.

The ***National Agricultural Statistics Service (NASS)*** conducts hundreds of surveys every year and prepares reports covering virtually every aspect of U.S. agriculture. As the USDA's statistical agency, NASS also conducts statistical science research on survey design, sampling, and other methodological issue areas.

The Department's plan reflects a vision to use the best available science to expand economic opportunity through innovation, to promote agriculture production sustainability that better nourishes Americans while also helping to feed others throughout the world, and to preserve and conserve our Nation's natural resources. Our commitment to sustainable agriculture is in the sense of the recent National Research Council report, which defined sustainable agriculture as (1) producing enough to satisfy human needs, (2) enhancing environmental quality and protecting the natural resource base, (3) being profitable, and (4) increasing the quality of life for farmers, farm workers, and society as a whole. The use of sustainable agriculture as a guiding framework is an underlying assumption throughout our plan, as well as an explicit component of many of the goals and strategies. Fully half of the organizations that provided formal input to the roadmap included this concept.

II. Strategic approaches

This action plan describes a set of strategies and actions that relate to a goal that is either programmatic or supports administrative activities. There is another set of activities that relates to "how" our work will get done. These approaches reflect an overarching philosophy of integration and collaboration, of ethical behavior, and of a focus on the user of the information.

- We are taking a portfolio approach to optimize the investment in USDA science. We take advantage of our intramural capacity in science and statistics and seek alignment with our investment in projects funded through our extramural programs. We thus capitalize on our ability to do long-term, broadscale science (stability) and to be nimble by funding universities and other research institutions as new questions or gaps in

capacity emerge (flexibility). The university partnership is strengthened through competitive, peer reviewed research.

- We are leveraging our strong foundational research and statistical information capacity, including a sustained investment in research that supports production agriculture, to spur innovation and respond to emerging issues and opportunities. Ensuring the intellectual capital in traditional agricultural and natural resource disciplines must be sustained if we are to meet USDA's research needs into the future. Maintaining a core program in the traditional disciplines and approaches is the backbone for emerging disciplines and 21st century problems.
- We are promoting scientific integrity in the policies of USDA, both in the doing of science as well as in the use of science. In this, we are aligned with the December 17, 2010, letter from Dr. John Holdren, Director of the Office of Science and Technology Policy, charging all Departments and agencies at the Federal level to develop sound policies that "ensure a culture of scientific integrity" and "strengthen the actual and perceived credibility of Government research."
- We are moving science into practice through our technology transfer and extension efforts; promoting innovation in agriculture, forestry, and conservation; and through informing program and policy decisions at the community, State, and national levels. More than that, we have programs that address the continuum of learning, from K-12 education, to undergraduate and graduate education, to continuing education of professionals. Keeping the pipeline of students ready to move into the agricultural science and research jobs of the future has to be a key focus today if America is going to win the global marketplace of tomorrow. In this way, REE agencies put science and information into the hands of policy makers, practitioners, educators, and the interested public, thereby enhancing USDA's mission.

"It is simply service that measures success" -George Washington Carver

- **REE's Guiding Principles**

- *We use our disciplinary building blocks and ongoing core programs as the foundation of our ability to anticipate and respond to emerging issues and opportunities.*
- *We create an environment of inquiry and innovation.*
- *We use our capacity in research, in education, in extension, and in statistical measures to achieve our goals.*
- *Our education and extension efforts advance all REE goals. They are the mechanisms that enable us to connect our information and knowledge to users and practitioners.*
- *We leverage our work and resources through our partners in the State-based universities, other Federal science agencies, and with the private sector.*
- *Our programs—from competitive grants to universities, to the Census of Agriculture—from more than a century of transformative science to leading-edge economic research, inform USDA policy decisions.*
- *We cultivate a world-class, broadly inclusive, research and statistical workforce.*
- *We support excellence in research, in information gathering, and in education and extension through a capable and responsive organization.*
- *Our infrastructure—the National Arboretum, the National Agricultural Library, our labs, and our experimental farms and watersheds—is a valuable asset and a legacy for science and the American people. We are committed to leveraging our assets to achieve sustainability and increase capacity to solve future problems.*
- *We lead progress in improving sustainable agricultural systems, integrating productivity, profitability, and stewardship of natural and human resources, upon which agriculture and land stewardship depend.*

III. Goals: Challenges, Strategies, and Actions

GOAL 1. Education and Science Literacy

CHALLENGE: Over the next decade it is expected that there will be an increase in attrition of the workforce in the agricultural industry and the academic sectors. These concerns are well founded considering that the number of students enrolling in the food and agriculture sciences is decreasing and many universities have either dropped or consolidated programs at the baccalaureate levels. In fact, there is less interest among youth to pursue a career in the sciences. The number of students going into graduate programs has also declined tremendously and if this trend continues, we will be looking at acute workforce shortages in these areas. The estimated average age of U.S. farmers in 2007 was 57.1, up from 55.3 in 2002 and is about 16 years older than an American worker in general. Only about 55% of the 54,000 predicted annual agriculture-related jobs between 2010 and 2015 will be filled by graduates of agriculture sciences, according to a report by Purdue University and NIFA. The economic conditions in rural areas make it difficult to attract and retain workers, particularly young people who leave rural areas for better social and career options.

If America is going to hold its leadership position in the global economy, it is vital that we leverage the talents and skills of students across the broad spectrum of economic, ethnic, and social segments of our Nation. The innovative solution to feeding the world and providing for its energy needs will only be found in attracting students to the agricultural sciences and supporting their achievement.

Some factors that contribute to the difficulty in recruiting people to study and work in the agricultural sector includes: (1) poor image and promotion of agriculture, (2) lack of innovative education and training initiatives, (3) elimination of agriculture subjects at the secondary levels hampers early recruitment, (4) dearth of qualified science teachers from elementary to secondary levels or qualified trainers in higher education, (5) unclear career pathways in agriculture, and (6) disconnect between 2-year vocational institutions and baccalaureate granting institutions.

REE ROLE: Recruit, cultivate, and develop the next generation of scientists, leaders, and a highly-skilled workforce for food, agriculture, environmental systems, and life sciences to out-educate our global competitors.

STRATEGIES AND ACTIONS:

Develop a well-integrated and coordinated approach to populate the academic pipeline.

Actionable items

- Increase STEM focus at the middle school to high school level that is highly relevant to agriculture sciences; combining formal and informal learning strategies [explore collaboration within USDA (e.g., NIFA, ARS, NASS, ERS) and between USDA, the Department of Education, and NSF].
- Scholarship program for 2-year vocational and baccalaureate levels, combined with agricultural industry internships and/or academic research internships [explore

- collaboration among USDA agencies (e.g., NIFA, ARS, and FS), and with other Federal agencies such as NPS and NSF].
- Utilize fellowship and traineeship for graduate and post graduate studies in agriculture shortage areas; and increase the visibility of these programs through a variety of media, Web-based or online communications materials [collaboration within USDA agencies, i.e., NIFA, ARS, ERS, FS, and other Federal agencies, i.e. NSF, NPS, and the National Oceanic and Atmospheric Administration (NOAA)].

Provide educational and training opportunities to beginning farmers and ranchers.

Actionable items

- Provide education, training, internships, and mentorships to beginning farmers and ranchers (collaboration with NIFA, OAO, OTR, FSA, and other agencies).
- Develop 2-year degree courses at vocational/technical community colleges (NIFA in collaboration with NSF's ATE program).
- Develop and disseminate new technologies and information that will help beginning farmers and ranchers succeed (NIFA in collaboration with other USDA agencies).

Strengthen the science capacity at minority-serving institutions (explore collaboration with Federal agencies- NIFA, ARS, ERS, FS, NPS, NSF, NOAA, the Department of Education, the Department of Labor, the National Aeronautics and Space Administration, and the National Institutes of Health).

Actionable items

- Support research and research infrastructure and develop the culture for meaningful collaborations with other institutions and Federal research laboratories.
- Training and development of students for a competitive and skilled workforce or further education.
- Provide opportunity for faculty development to enhance teaching skills and/or build competitive grant writing capacity.

Enhance existing partnerships with land-grant universities and other educational organizations to identify and assist minority producers, beginning farmers, and women producers and remove program barriers to participation (NIFA).

Actionable items

- Enhance access to government programs and grants to educational organizations that identify and assist minority producers, beginning farmers, and women producers.
- Increasing funding to address the unique needs of minority producers, beginning farmers, and women producers.

Leverage technology and innovation to distribute business tools, information, and resources, and use non-formal education programs, outreach, 4-H, and other youth development programs to transfer knowledge and technology (NIFA).

Actionable items

- Increase STEM educational content, aligned with respective state standards, of the Agriculture in the Classroom (AITC) Program's National Resource Directory electronic database.

- Complete a revised Food and Fiber Systems Curriculum Framework for use as a tool by teachers, curricular specialists, and industry professionals to promote agricultural science literacy among K-12 students.
- 4-H National Headquarters and AITC at NIFA will work strategically with USDA in developing curricula and learning opportunities that align with USDA priorities, which reach youth in non-formal and formal settings. Collaborate on the annual 4-H National Youth Science Day in October to highlight USDA resources relevant to the science day topic.
- REE agencies will increase collaboration with extension communities of practice that target youth audiences, including the Youth Science, Engineering and Technology for Life community.
- Explore potential partnerships with foundations or other organizations to provide opportunities for high school science students to work on short-term science and innovation projects in USDA research labs in support of STEM initiatives.

GOAL 2. Rural Prosperity

CHALLENGE: Rural America has witnessed enormous change over the course of the last century. As agriculture’s contribution to employment and income declined, many rural areas shifted to other activities, including manufacturing and service-, recreation-, and retirement-based industries. The response to these changes reflects rural America’s great geographic, economic, and social diversity: while many communities well-positioned to take advantage of new opportunities have increased in vitality, many others have lost their economic reason to exist and have experienced various degrees of distress, including persistent outmigration, poverty, and/or stagnant labor markets. In some cases, communities have ceased to exist altogether. How rural areas position themselves to better compete in a global environment where skills, knowledge, and innovation are key drivers of economic growth and prosperity is a central element in the debate about the future of rural America.

REE ROLE: Provide effective research, education, and extension that inform public and private decision-making in support of rural and community development.

STRATEGIES AND ACTIONS:

Establish the determinants of rural prosperity and develop indicators to measure regional assets and performance.

Actionable items

- Develop conceptual framework for measuring rural wealth creation and understanding its role in regional economic development.
- Increase knowledge of the role of entrepreneurial activity in local and regional development—how new products and services, new processes, and new markets are related to rural employment growth.
- Establish the interactions between community assets and business vitality and growth, with emphasis on the drivers of growth in distressed and low-asset rural areas.
- Increase knowledge about the importance of return migration in stemming rural and small-town population loss, the role return migrants play in building economic

prosperity in rural communities, and what rural communities can do to increase levels of return migration.

- Increase knowledge about the importance of regional innovation and collaboration for sustainable rural economic growth.

Conduct research, education, and extension to help farmers, ranchers, and rural communities take advantage of new and growing market opportunities (such as local and regional food systems and organic agriculture) and technologies (such as broadband, green technologies, and renewable energies) and spur much-needed innovation.

Actionable items

- Investigate mechanisms for overcoming the impediments to broadband technology access and adoption in rural areas.
- Identify and transfer knowledge about the characteristics and factors that contribute to the success of local and regional food systems and their contribution to economic investment and development and human well-being.
- Develop and share knowledge to help stakeholders implement successful organic production and marketing systems in response to growing consumer demand.
- Develop and share knowledge about emerging green technologies and green economy initiatives, and their potential contributions for economic development in rural areas.

Support information and technology transfer and translational research, “transformational extension,” to inform citizens and enable and support vibrant and resilient communities.

Actionable items

- Develop partnerships with community/economic development organizations to promote adoption of USDA science-based research outcomes for commercialization by rural entities.
- Help small businesses develop partnerships with colleges, universities, and/or Federal laboratories for research, development, and commercialization of new technologies, products, and services to enhance the vitality of rural communities.
- Improve rural data dissemination through the creation of new electronic geographic information systems.
- Provide information services to rural communities, officials, organizations and citizens through the National Agricultural Library’s (NAL) Rural Information Center.

Build new partnerships with underserved and non-traditional populations.

Actionable items

- Partner with national level community based organizations (CBO’s) to solicit improvement to 2012 Census of Agriculture mail list for underserved populations.
- Develop new data collection strategies to improve quality of data for underserved populations.
- Promote partnerships among colleges, universities, local and regional CBOs, field based organizations, and extension to identify and address the needs of underserved populations.

Provide statistical data and analysis to promote efficient domestic agricultural production and marketing systems.

Actionable items

- Conduct Census of Agriculture content test in 2011 to finalize questionnaire.
- Provide statistically sound information for expanding economic opportunities by conducting the 2012 Census of Agriculture.
- Develop and implement a rotational agricultural renewable energy survey and data series. Release first results of energy production on farms in early 2011.
- Provide commodity and food market information that increases the efficiency and effectiveness of private domestic agricultural production and marketing systems.
- Ensure Census of Agriculture covers small farms.

GOAL 3. Biofuels

CHALLENGE: EPA has finalized a rule implementing the long-term renewable fuels mandate of 36 billion gallons by 2022, established by Congress. The Renewable Fuels Standard requires biofuels production to grow from last year's 11.1 billion gallons to 36 billion gallons in 2022, with 21 billion gallons to come from advanced biofuels. About 24 million acres of dedicated feedstock crops will be required to produce these advanced biofuels. Increasing renewable fuels will reduce dependence on oil by more than 328 million barrels a year and reduce greenhouse gas emissions more than 138 million metric tons a year when fully phased in by 2022. By 2015, 5.5 billion gallons of advanced biofuels is required. Strategic research, demonstration, commercialization, extension, and education programs are needed to meet these national goals. The REE mission area takes into consideration the advice and recommendations received from outside sources, including the Biomass Research and Development Initiative Technical Advisory Committee and the National Agricultural Research, Education, Extension, and Economics Advisory Board and Renewable Energy Committee.

REE ROLE: Out-innovate and out-build the rest of the world by assisting in creating energy efficiency and independence through integration of more economically and environmentally sustainable regional-based biomass production systems into existing agricultural systems as complete bioenergy supply chains, providing clean biobased energy and rural economic development. Challenge our scientists to invent and develop new technologies to meet our Nation's energy needs.

STRATEGIES AND ACTIONS:

Increase biomass production efficiency to reduce production and biorefinery costs: conduct biomass plant improvement research and development for advanced bioenergy feedstocks for use in biofuels and biobased products, including understanding the molecular basis for key plant traits and improving germplasm and varieties for energy crops; develop regionally-based sustainable new feedstock production systems for bioenergy feedstocks; and develop feedstock logistics and conversion technologies suitable to near-farm scales.

Actionable items

- Implement and leverage the five established USDA Regional Biomass Research Centers and NIFA-funded projects, in cooperation with Forest Service Research and Development and other external resources, to effectively integrate knowledge about more sustainable crop and forest production bioenergy systems.
- Identify new genes that control biomass and develop improved germplasm for bioenergy feedstocks.
- Protect traditional germplasm in native plants through partnership with ARS, APHIS, and other Federal agencies.
- Conduct research on near-farm scale thermochemical conversion technologies, such as pyrolysis and/or torrefaction, for advanced biodiesel biofuel production that can accommodate feedstock flexibility.
- Conduct and integrate research to reduce risks and improve the profitability of first- and second-generation biorefining, including: development of co-products as biobased chemicals and other high value products (e.g. glycerol-based polymers), and integration of bioenergy research with research on other renewable energy production, climate change, environmental improvement, food, and other biobased production, to diversify use of the rural landscape.

Incorporate biomass and dedicated feedstock crops into existing agriculture and agroforestry-based systems to increase diversity of the rural economy and sustainable land management

Actionable items

- Engage and use extension system in advancing knowledge in all aspects of bioenergy production, use, and conservation, to producers and end-users, including underserved and minority communities.
- Develop cost-effective waste-to-energy systems (using animal manures, crop and forest residues, and other residuals as feedstocks) to produce distributed heat and power.
- Expand effective communication and information sharing mechanisms, including the implementation of educational curricula, to prepare the needed workforce.
- Develop on-farm utilization of biorefinery co-products.
- Target multi-functional landscapes.

Address the uncertainties of expanded biomass and biofuel production to achieve benefits and avoid negative impacts on rural communities, economies, and ecosystem services and food, feed, and fiber by developing biophysical models to evaluate commercial scale bioenergy feedstock production systems and policies and their impacts on long-term productivity and other ecosystem services from underlying natural resources and developing the statistical information base and analytic capacity to understand and model economic and environmental benefits and impacts of biofuel production and bioenergy-related policies.

Actionable items

- Develop short- and long-term projections for crop and livestock production, prices, and trade and evaluate implications of bioenergy production for farm income,

- commodity program budget expenditures, food prices, and other indicators of farm performance.
- Develop models of bioenergy production, which incorporate social, economic, and environmental factors in order to identify sustainable outcomes.
 - Continue expanding current economic and biophysical models (e.g., the Greenhouse gas Reduction Agricultural Carbon Enhancement tool and the Conservation Effects Assessment Project (CEAP) Water Assessment Study) to include dedicated bioenergy feedstocks and linkages to outcomes on resource use, environmental quality (e.g., long-term productivity and ecosystem services provided and greenhouse gas emissions).
 - Conduct studies to examine Federal policy and identify action steps to develop more sustainable production systems, which create reliable rural development and avoid unintended environmental consequences.

GOAL 4. Responding to Climate Change

CHALLENGE: Agriculture, forest, and range production systems are dramatically affected by climate variability and change. Agricultural and forestry producers, land managers, and other decision makers need information, technologies, and decision-support tools about greenhouse gas mitigation, adaptation strategies, and policy outcomes. Crop, animal, forest, and range management strategies must take climate variability into account to improve sustainability over the long term. The potential for forests and agricultural lands to serve as carbon sinks and to reduce greenhouse gas emissions must be quantified to support sound policies and environmental markets. Outreach and extension networks must be implemented to advance the incorporation of these climate-change mitigation and adaptation strategies into management practices and utilize scientific findings for restoration projects, planning, and prescriptions.

REE ROLE: Provide science-based knowledge that empowers farmers, foresters, ranchers, land owners, resource managers, policy-makers, and Federal agencies to manage the risks, challenges, and opportunities of climate change, and position decision makers to reduce emissions of atmospheric greenhouse gases and enhance carbon sequestration.

STRATEGIES AND ACTIONS:

Explain the processes driving the direct and indirect effects of climate change on natural and managed ecosystems, including feedbacks to the climate system.

Actionable items

- Identify and quantify the effects of changing climate, climate variability, and atmospheric composition on agriculture, rangeland, and forest ecosystems productivity and sustainability (ARS, NIFA, NASS, FS, NRCS).
- Project the decadal impacts of global climate changes on the global-through-urban earth system in support of air quality and agro-ecosystem policy analyses and management planning (NIFA).
- Explain the processes and mechanisms that determine how climate change affects invasive species, weeds, pathogens, and insects and determine the effects of changing

- climate stresses on vector behavior, distribution, and host susceptibility for different genotypes of crops, livestock, and forest species (ARS, NIFA).
- Project economic consequences and effects on legal status of landowners of climate change for natural and managed ecosystems, including the well-being of producers—including beginning and socially disadvantaged farmers, agricultural markets, and ecosystem services (ERS).

Develop knowledge and tools to enable adaptation to climate change and to improve the resilience of natural and managed ecosystems and vulnerable populations.

Actionable items

- Create adaptation practices and systems (including “transformative” systems in the sense of NRC 2010, e.g., crop-livestock, organic, etc.) that sustain and increase the resiliency of crop, livestock, and forest tree production systems, biodiversity, and ecosystem services (ARS, NIFA).
- Expand evaluation of gene expression (phenology) to include traits associated with susceptibility or adaptation to climate change, the product being an expanded centralized marker, and trait database for key plant and animal commodities, to be used by those responsible for marker-assisted breeding programs. Associate the database with extensive analysis tools that can be readily used by breeders who receive training in a nationally-coordinated education network (ARS, NIFA).
- Use population genetics, climate matching, and ecological niche assessment to project potential ranges of invasive pests, enabling future detection and mitigation (ARS, NIFA).
- Strengthen existing monitoring programs, such as the Forest Inventory Assessment and National Resources Inventory (NRI), and integrate them with other monitoring and data collection systems and research networks, such as Long Term Ecological Research sites, the National Ecological Observatory Network, and USDA Long Term Agroecosystem Research sites to track and manage changes in land use and related effects on ecosystem processes (ARS, NIFA, NASS, FS).
- Quantify implications of producer choices for adapting to climate change on agricultural markets; farm structure, including land ownership; agronomic practices; adoption of technology; and ecological systems, and determine impacts on subsistence food sources (ERS).

Develop knowledge and tools to enhance the contribution of agriculture, forestry, grasslands, and other land management practices to mitigate atmospheric greenhouse gas (GHG) emissions.

Actionable items

- Evaluate biofuel cropping systems for feedstock production, greenhouse gas mitigation, and other ecosystem services (ARS, NIFA).
- Develop information and technologies, including life cycle inventory, that build stakeholder capacity for estimating, measuring, tracking, and minimizing net GHG emissions per unit of commodity produced at agricultural and forestry production scales (ARS, NIFA).
- Evaluate economic, GHG, and other environmental implications of alternative approaches to the design and implementation of GHG mitigation policies in the

- agriculture and forest sectors; apply new methodologies from behavioral economics to identify farmer and rancher behavioral factors likely to affect their participation in, and the performance of, offset markets and incentive programs (ERS).
- Develop and transfer knowledge to producers, land managers, and other decision makers about the GHG mitigation potential of “transformative” agricultural systems (e.g., NRC, 2010) to mitigate GHG emissions while providing other environmental, economic, and social benefits (ARS, ERS, NIFA).
 - Strengthen international capacity for agricultural GHG mitigation by providing leadership to the Global Research Alliance on Agricultural Greenhouse Gases (ARS, ERS, NIFA).

Provide information and tools to USDA agencies, stakeholders, and collaborators to improve decision making.

Actionable items

- Widen the use of models and tools developed to assess adaptation and mitigation strategies by creating user-friendly interfaces that facilitate decision support for non-scientist end users, including new/beginning and socially disadvantaged farmers (ARS, ERS, NIFA).
- Deliver integrated scientific and technical information on climate change, tailored to the agricultural, forestry, and natural resource management communities (ARS, ERS, NIFA).
- Expand outreach and university extension and education activities in global change and climate, including internet-based information systems for stakeholder access to information they can use (ARS, ERS, NIFA).
- Establish partnerships with other Federal agencies such as NOAA, NASA, and the Environmental Protection Agency and international research agencies, such as the Consultative Group on International Agricultural Research (CGIAR) System for supporting cutting edge discovery, learning, and outreach programs (ARS, ERS, NIFA).
- Enhance remote sensing methods to assess impact of climate change on crop production (NASS).

GOAL 5. Water Availability and Quality

CHALLENGE: As population continues to increase across the U.S. and around the world, there is a growing demand for safe, reliable sources of water to meet the needs of Earth’s diverse and expanding population. In many parts of the world, issues of water availability and safety are central to ensuring international food security and political stability (GOAL #7). In the U.S., rising demands for water to support energy sector growth (GOAL #3), sustain environmental flows (i.e., ecosystem services) (GOAL #6), and satisfy the water-rights claims of Native Americans, present new challenges for agricultural water conservation. Especially in light of alterations to the supply and demand for water predicted with climate change (GOAL #4), farmers, ranchers, and rural communities will be increasingly susceptible to these new competing demands, as well as to a mounting pressure to provide more water for urban and urbanizing areas at the expense of (surface and ground) water that currently supports agriculture and rural communities. While historically, drought and the reliability and safety of rural and agricultural

water supplies were of concern primarily in the Western states, issues of agricultural water security have become a national challenge. In many areas, expanding urban populations and rising demands for water from non-agricultural sectors now encroach on water supplies traditionally reserved for irrigated agriculture. In other areas, ground and irrigation water supplies are being depleted or contaminated by agricultural use. Shifts in the allocation and safety of these water resources could have dramatic impacts on the long-term supply of food and fiber in the U.S.

REE ROLE: Develop and provide the best available science and technology to inform decision-making and practices on water conservation, use, and quality.

STRATEGIES AND ACTIONS:

Foster a watershed/landscape-scale approach that encourages place-based agricultural water management and sustains U.S. agriculture and rural communities in the face of competing water demands.

Actionable items

- Improve the observational capability and data accessibility of ARS Benchmark Watersheds and Experimental Ranges (BW&ER), including updating and maintaining the STEWARDS database.
- Develop the Long-Term Agro-ecosystem Research (LTAR) network to improve communication and collaboration among existing ARS research facilities.
- Connect ARS LTAR and BW&ER networks with the FS Experimental Forests and Ranges (EF&R) network to investigate climate change influences on water resource management across a gradient from natural and managed ecosystems, to agricultural and urban ecosystems (ARS, FS).
- Develop a reference baseline for measuring changes in production capacity in response to changing environmental conditions and management decisions (ARS).
- Identify universal hydro-climatic descriptors of watersheds and determine the significance of historical trends in temperature, precipitation, and runoff across North America (ARS, FS).
- Continue development and validation of ARS watershed and management simulation models to treat a broader spectrum of conditions, management scenarios, ecosystem services, economics, and crop production.
- Evolve NIFA's existing Integrated Water Program and other potential funding mechanisms to address regional, place-based water initiatives (e.g., Chesapeake Bay, Great Lakes, etc.)(NIFA, FS, NRCS).
- Expand the NAL's Water Quality Information Center to provide USDA watershed research results (ARS, FS).
- Evaluate changes in watershed health and function in response to management, natural disturbances, and atmospheric deposition (ARS, FS, NIFA).
- Standardize methods and protocols for intensively monitored watersheds (ARS, FS, NIFA).
- Improve the knowledge of water rights legal systems by partnering with NAL and the National Agricultural Law Center.

Provide research and decision support tools to: increase the effectiveness of USDA conservation policies, programs, and practices; raise the ratio of conservation benefit/conservation investment; and facilitate the transfer of research advances to practical implementation.

Actionable items

- Develop new and/or improved conservation practices, and strategies for practice placement, to maximize conservation benefits at the watershed scale while minimizing conservation investments (ARS, NIFA, NRCS, FS).
- Develop user-friendly decision support tools for practitioners (conservationists, land managers, farmers, ranchers, and the tribal and reservation communities) that use state-of-the-art USDA research to rapidly and effectively solve practical problems at the field, landscape, or watershed scale (ARS, NIFA).
- Improve our understanding of the aggregate effects of conservation practices at the watershed scale (ARS, NIFA, NRCS, FS).
- Develop a better understanding of the economic impacts and social drivers of conservation practice adoption in rural, agricultural, and urbanizing watersheds (ARS, FS, NIFA).
- Reconstitute an effective Partnership Management Team (PMT) to integrate ARS and NIFA research with NRCS and FS program delivery. Work with FS to develop collaboration between researchers and managers using the experimental watershed network.
- Support the development of tools such as the FS Directory Watershed Context, which will help USDA employees and others seeking information about watersheds.

Improve the efficiency of water use (particularly for irrigation) and develop and extend science and technology to achieve the maximum “crop per drop” for agricultural goods and services.

Actionable items

- Conduct the Farm and Ranch Irrigation Survey for the year 2013 to provide needed information concerning crop water use, irrigation system and water management practices, water quantity by sources, and other information necessary to evaluate agriculture’s impact on USDA goals for water resource management and sustaining rural economies (NASS).
- Invest in research, development, and extension of new irrigation techniques and timing of application of limited water resources, including strategies for water reuse (ARS, NIFA).
- Promote research addressing the economics of conserving ‘irrigation production systems,’ i.e., the integration of conserving on-farm water-management practices with high-efficiency irrigation applications systems, encouraging both reduced applied water and crop-water consumption while maximizing farm income (NIFA).
- Support research and extension on innovative crop management systems and integrated crop-livestock systems that may achieve dramatic improvements in water conservation and quality and other ecosystem services (“transformative” systems in the sense of NRC 2010) (NIFA).
- Continue implementation of NIFA’s Agricultural Water Security Initiative with focus on socio-economic research and extension to increase adoption of appropriate

practices and technologies (including alternative crops) to achieve increased water conservation at the watershed scale.

Expand and/or elevate existing, and encourage new, Federal partnerships to promote water conservation at watershed, landscape, and regional scales in agricultural, rural, and urbanizing communities, and reduce the impacts of climatic disturbances.

Actionable items

- Propose new partnership with the Department of the Interior Bureau of Reclamation (BOR), USGS, and EPA to address areas of common interest, conduct cooperative research, and promote adoption of research outcomes to deliver/conservate water (ARS, FS, NRCS).
- Continue cooperation with NOAA and other Federal agencies via the National Integrated Drought Information System (NIDIS) to promote place-based research and extension aimed at improving community drought preparedness (ARS, ERS, FS, NIFA, NRCS).
- Continue to explore potential partnerships with EPA, USACE, USGS, BLM, USFS, and other Federal agencies to improve water resource management in working landscapes (ARS, FS, NRCS, FSA, NIFA).

Transform youth water education to support USDA’s vision for the future of water management.

Actionable items

- Integrate non-traditional approaches to water education (social, cultural, artistic, etc.) with traditional biophysical approaches in all new water curriculum development funded through NIFA grant programs. Highlight concepts such as water “footprints” and “life-cycle analysis” in new curricula.
- Support the development of educational materials on the water cycle and water conservation through the Natural Inquirer and FS Conservation Education (FS).
- Support partnerships that integrate new approaches to water education (FS, REE).

Provide research and decision-support tools to maintain water availability and safety in a changing global environment.

Actionable items

- Identify components of the hydrologic system that are most sensitive to projected climate variability and determine their potential impacts on agricultural productivity, natural resources, and land conservation (ARS, FS, NRCS).
- Estimate the impacts of projected climate variability on regional water availability and quality (including sediment yield) across diverse physiographic regions of the U.S. and their associated implications for conservation needs and agricultural productivity (ARS, FS, NRCS).
- Develop climate-informed decision support systems to sustain US agricultural production capacity and natural resources in light of climate-driven changes in water availability (ARS).
- Develop regional use estimates of the “water footprint” (surface and ground) of agricultural production systems (NIFA).

- Determine social, economic, and/or cultural circumstances or practices that promote or serve as barriers to reducing the water footprint of agricultural production, and develop outreach/extension programs that lower these barriers and promote the adoption of water conserving practices and technologies in rural and agricultural communities (NIFA).

Develop and refine research and decision-support tools to understand the water implications of USDA’s evolving bioenergy strategy to contribute to the development of sustainable bioenergy production systems.

Actionable items

- Evaluate the water implications of bioenergy feedstock production at watershed, landscape, and regional scales to reduce conflicts between food and fuel production and the provision of ecosystems services, particularly the availability of adequate supplies of clean, fresh water (ARS, ERS, FS, NIFA).

Provide statistical data to support management of productive working cropland (ERS, NASS).

Actionable items

- Provide additional data on crop conditions, soil moisture, and/or drought monitoring by publishing cropland data layer technology for all 48 contiguous states.
- Summarize the 2012 Census of Agriculture by six-digit Hydrologic Unit Code and publish results in a Census Watershed Publication to enable better management of water resources at the local level.
- Conduct research and explore new scientific and technological advances to enhance the quality, accuracy, and consistency of statistics, specifically in the areas of geographic information systems and remote sensing.
- Evaluate trends and changes in production agriculture and adjust the Farm and Ranch Irrigation Survey and Agricultural Resource Management Survey programs accordingly.

GOAL 6. Landscape-scale Conservation and Management

CHALLENGE: Well-managed agricultural and forest land supplies important non-market goods and services for our environment. Farms, forests, and ranch lands provide food and cover for wildlife, help control flooding, reduce erosion, protect wetlands and watersheds, improve water quality and quantity, store carbon, and maintain air quality. They can absorb and filter wastewater and provide groundwater recharge. Well-managed agricultural lands also provide cultural and aesthetic benefits. With a rapidly increasing world population and expanding global markets, saving American farmlands, ranches, and forests is a prudent investment in the world’s food, fiber and energy supply and the nation’s economic future.

Landscapes are a foundation of rural economic opportunities and focal points for addressing issues through a concentration of available resources that integrate leading-edge science, including assessments, adaptation tactics, monitoring, predictive models, and management actions. Science and technology development within landscapes is collaborative in nature and utilizes past and current work. Working across landscape levels enables focused investments in

land management science and technology to better meet the needs of land owners and managers. Effective and efficient solutions will be evaluated for other landscapes.

Updated USDA fertilizer nitrogen recommendations optimized for production and environmental goals are needed along with improved bioavailability of soil and applied nitrogen control technologies to mitigate nitrogen losses, predictive and hindcasting tools to assess source candidates for mitigation, and improved process-based models to analyze nitrogen life cycle in agricultural systems. Linking these tools to policy options and evaluation of policy strategies and markets are needed to encourage better and more efficient management of nitrogen

REE ROLE: In collaboration with USDA sister agencies such as the Forest Service Research and Development and the Office of Environmental Markets, develop and provide the best available science and technologies to inform U.S. government policies and programs and to support application of land management practices that improve the economic and environmental sustainability of our Nation’s working farms, ranches, and forests.

STRATEGIES AND ACTIONS:

Understand determinants of producer adoptions of conservation practices, including the role of markets for ecosystem services.

Actionable items

- Evaluate the economic, demographic, resource, and climate issues that affect the adoption of conservation practices and influence the decision to participate in conservation programs (ERS).
- Evaluate the effectiveness of a range of agri-environmental program designs for promoting the provisions of ecosystem services from agriculture, including financial incentives, compliance, and market-based approaches. The research would include an assessment of the implications of multiple program objectives, such as water quality, wildlife habitat, and farm income, on policy design (ERS).
- Provide a statistical information base on agricultural land usage and conservation practices as a basis for understanding the determinants of government policy on land use (NASS).
- Develop a coordinated agenda for research to identify and measure ecosystem services that different conservation and management practices and systems can produce (ARS and NIFA).
- Working with NRCS, NIFA funds competitive outreach to implement the lessons learned from two synthesis projects of thirteen Conservation Effects Assessment Project (CEAP) watersheds that evaluated conservation practices and socioeconomic implications across the U.S.
- Compile a complete database of the current research on ecosystem services and closely related topics and synthesizes research activities from both the NRCS special emphasis watersheds and associated ARS benchmark watersheds to develop decision support for appropriate conservation practice application in critical watersheds (ARS).

- Identify and analyze the barriers to sustainable ecosystem service management and formulates solutions to overcome these barriers, including those encountered by new/beginning and socially disadvantaged farmers and ranchers (NIFA).
- Synthesize the suite of ecosystem services models and evaluates their applicability and effectiveness for use in environmental credit trading markets (ARS).
- Focus science and technology development efforts at the landscape level, targeting place-based conservation and management options (USFS Research & Development (USFSR&D)).

Develop an integrated, multimedia (air, water, soil, biomass, wildlife) / multidisciplinary program that takes a mass balance approach to conservation, improved efficiency, control technologies, environmental credit trading, and process-based models for reactive nitrogen.

Actionable items

- Fund competitive programming to update USDA fertilizer nitrogen recommendations optimized for production and environmental goals, improved bioavailability of soil and applied nitrogen, control technologies to mitigate nitrogen losses, predictive and hindcasting tools to assess source candidates for mitigation, and improved process-based models to analyze nitrogen life cycle in agricultural systems (NIFA).
- Fund an educational program to reduce protein consumption in the US through a more balanced plant versus animal protein diet, improving efficiency of uptake of amino acids in food, leading to reduced obesity, improved health, and reduced nitrogen in human waste, while considering culturally appropriate foods (NIFA).
- Fund a functional genomics and plant breeding program to understand nitrogen fixation in soybeans and transfer this functionality to perennial commodity crops, corn, wheat, and cotton, leading to reductions in nitrogen fertilizer application (NIFA).
- Develop a program to improve efficiency of feed conversion of crude protein in the animal gut and evaluates new feedstocks as sources of amino acids for animal production, such as waste streams from biofuel production, to reduce the nitrogen in animal waste (NIFA and ARS).
- Create a program to develop bioproduct processes that are economically viable and that do not adversely impact the environment. For example, utilize byproducts in waste streams from biofuel production as a concentrated source of nitrogen for feed or fertilizer (NIFA and ARS).
- Develop and evaluate policy strategies and markets to encourage better and more efficient management of nitrogen (e.g., trade, conserve, and remediate reactive nitrogen) (NIFA and ERS).
- Develop programming to develop a holistic systems approach, both towards understanding nutrient dynamics in *transformative* (e.g., organic, integrated crop-livestock, and alternative livestock) sustainable systems, and applying this knowledge in extension and education programs, including consideration of culturally appropriate foods (NIFA and ARS).

Understand and share the determinants that retain and foster economically viable and environmentally sustainable livestock and forage production systems

Actionable items

- Develop a program to evaluate the impacts of cellulosic energy production on forage-based livestock systems (NIFA and ARS).
- Develop programming to understand the adaptation requirements of forage-based livestock systems to extreme climatic changes (i.g., how to manage risk).
- ARS develops inventory and monitoring tools to optimally control the spread of invasive weeds in terms of reducing productivity losses to wildfire, altering wildlife habitats, and loss of biodiversity (NIFA and ARS).
- Develop a program to evaluate more complex mixtures (e.g., functional groups) of pasture grasses and legumes as a risk reduction strategy and to optimally produce biomass for bioenergy production (ARS).
- Develop a program to investigate the impacts on the phenology and spread of poisonous plants due to changing climate (ARS).

Advance the use of agroforestry as a viable agricultural option for meeting the multiple demands of food, fiber, feed, fuel, and natural resource conservation from these lands.

Actionable items

- Develop knowledge and technologies to improve the application of agroforestry practices and principles in: protecting water and soil resources; building landscape-level resiliency to climate change impacts; reconnecting ecological services across rural-urban lands and communities; providing innovative and sustainable bioenergy production systems; creating multi-purpose landscapes that can produce food, fiber, and energy, and protect natural resources (USFS R&D).

Manage agricultural watersheds and landscapes to improve the delivery of ecosystem services while sustaining or enhancing agricultural production.

Actionable items

- Develop robust indicators, statistics, and biome-specific metrics of the: 1) spatial connectivity of landscape elements; 2) quantity and quality of ecosystem services provided by agricultural landscapes; and 3) commodity values of ecosystem services delivered from working lands.
- Partner with other Federal agencies, such as NOAA, NASA, and EPA, to develop an integrated management plan for the agricultural watersheds and landscapes.

GOAL 7. Food Security -- Local to Global

CHALLENGE: The future of U.S. agriculture depends on economic growth in the developing countries for expanding feed and food export markets; generating beneficial knowledge, information, and technologies for adaptation and mitigation to climate change; helping protect U.S. crops, livestock, and ecosystem from the threat of exotic pests and diseases; and improving the quality and safety of imported food products. In developing countries with largely agrarian populations, vibrant and sustainable agricultural production is the very basis for broad economic development and stability. Until a nation has the capacity to feed, clothe, and shelter its rural and native populations, labor and capital cannot be freed for the pursuit of growth in other economic sectors. Agricultural development depends on an information base to facilitate

economic decisions on access to affordable and appropriate technologies that can improve food production; natural resource management, harvesting, storage, and distribution; and advance the health and safety of all citizens while minimizing environmental impacts.

REE ROLE: Develop and transfer knowledge and skills that promote environmentally and economically sustainable² agricultural systems globally, thereby enhancing global food security and, in doing so, strengthen American agriculture.

STRATEGIES AND ACTIONS:

Invest in research, development, and extension of new varieties, practices, and systems of interest, both domestically and in developing countries, to safely and sustainably increase animal and crop production and its nutritional value.

Actionable items

- Enhance the capacity of genetic resources and genome databases for target crops, animals, and priority pathogens, and expand the capacity of plant, animal, and microbial collections to manage increased numbers of new experimental genomic/genetic stocks (ARS, NIFA).
- Develop and extend crop and agricultural genetic products, production technologies, and practices with specific environmental and economic value to improve production efficiencies, product quality, plant and animal health, and animal well-being (ARS, NIFA).
- Develop and extend improved feed ingredients, nutritional technologies, reproduction technologies, and animal health products for improved efficiency, productivity and well-being for agricultural animals (ARS, NIFA).
- Develop and extend technologies and practices to enhance the safety and quality of food and other agricultural products through improved pre- and post-harvest management, storage, and distribution (ARS, NIFA).
- Develop and extend knowledge, practices, and systems that are climate resilient to enhance the management of soil, water, and biodiversity to improve resource stewardship and increase economic and social returns (ARS, NIFA).
- Develop and extend effective, affordable, and environmentally-sound integrated control strategies to reduce losses caused by diseases, pests, and weeds, including early detection, identification, monitoring, and implementing biologically-based and areawide strategies to manage key native and invasive species and postharvest pests (ARS, NIFA).
- Link with other USDA in-country activities to extend research by taking basic research and applying it creatively.

Invest in research, development, and extension to minimize human and environmental health risks from animal production, domestically and in developing countries.

Actionable items

² "Sustainable" as used here refers to the National Research Council's definition of sustainability as put forth in the "Toward Sustainable Agricultural Systems in the 21st Century" Report from June, 2010.

- Partner with other Federal agencies, such as HHS, and develop strategies to transfer technologies and capacity to diagnose and control vector-borne and zoonotic diseases that impact livestock and human health (ARS, NIFA).
- Explore partnership with NIH to develop and extend alternatives to antibiotics, including pre- and probiotics, biotherapeutics, and immune modulators to enhance animal health and production under field conditions (ARS, NIFA).
- Expand research capacity for current and emerging vector-borne and foreign animal diseases that will both help control disease in the countries of origin as well as provide valuable information on control strategies in the event of the entry into the U.S. (ARS, NIFA).

Invest in data development, analysis, and dissemination to improve the understanding of agriculture markets, domestic and trade policies, and other factors which impact food systems in developing countries.

Actionable items

- Provide technical assistance to improve agricultural statistics systems in developing and transitioning countries (ERS, NASS).
- Analyze the performance of domestic, international, and regional markets and their impacts on global food security (ERS).
- Develop estimates of international agricultural productivity growth to improve understanding of patterns of growth and analyze how different factors—including government policies—influence productivity trends (ERS).
- Produce annual Food Security Assessments covering 70 food insecure countries that analyze the current food security situation, projects food security developments over the next decade, and analyzes the effect of alternative economic and policy alternatives on global food security (ERS).

Develop and populate a framework for understanding the sustainability (productivity, economic, and environmental) outcomes of agriculture/food/forestry practices and systems.

Actionable items

- Develop a system for capturing and delivering data and information on environmental, economic, and social consequences of food, agriculture, and forestry systems and processes over the life cycle of product supply chains (ARS, NIFA).
- Develop life-cycle inventory data on environmental, economic, behavioral, and social impacts of key agriculture-related processes to fill gaps in the framework (ARS, NIFA).
- Develop, assess, and share knowledge about transformative systems approaches to improving the sustainability of agriculture (ARS, NIFA).

GOAL 8. Linking Agricultural Production and Trade

CHALLENGE: The United States is a key player in the global marketplace of food and agriculture. To remain competitive, the U.S. must continue to create new knowledge, and develop and advance products that provide value to American agriculture and the food production enterprise. Fundamental knowledge and innovative technology such as biotechnology can contribute to improved gains in agricultural productivity. Innovative

technology must be accompanied by assurance of safety and acceptance. Research conducted within REE and by its partners is critical to the decisions made by regulators and policy makers regarding safety of newly developed products and on U.S. trade policies.

REE ROLE: USDA REE science should out-innovate our competitors around the world with technologies that enhance America’s ability to develop agricultural products and to maintain a leadership position in agricultural trade, while informing science-based regulations and policies, including those that impact trade.

STRATEGIES AND ACTIONS:

Generate new fundamental knowledge through research in genomic sciences and applications of systems approaches required to enhance the sustainability of agriculture while increasing productivity.

Actionable items

- Develop and support interconnected databases that enable researchers to generate and access new knowledge about the structure and function of plant genomes (ARS, NIFA).
- Develop improved tools for genetic and genomic analysis of complex genomes to support genetic improvement of food and other crop plants (ARS, NIFA).
- Identify and use genes and molecular processes that increase yield and improve composition and quality of crops (ARS, NIFA).

Preserve, characterize, and deploy genetic diversity to ensure economic and environmental sustainability and to maintain American agriculture leadership in a global, biobased economy.

Actionable items

- Develop effective methods to conserve plant, animal, and microbial genetic diversity for use in agriculture (ARS).
- Identify and utilize genetic diversity to develop novel traits and properties that will enable development of useful plant varieties and animal breeds (ARS, NIFA).

Conduct biotechnology risk and benefits assessment research that informs regulators, product development, and consumer acceptance, and provides information to FAS relevant to trade issues.

Actionable items

- Develop and implement new methods using transgenes that enhance the speed and efficiency of conventional plant breeding (ARS).
- Assess new biotechnology varieties to promote more sustainable agricultural systems and determine risks and benefits on the environment and economy, including technologies that promote the coexistence of different agricultural production systems (ARS, NIFA).
- Assess policies and management strategies for their ability to contribute to the coexistence of different agricultural production systems (ARS, NIFA).

Make research outcomes readily accessible to the public/consumers and to producers and processors through education and extension outreach.

Actionable items

- Develop and implement new programs to inform lay and scientific audiences, including new/beginning and socially disadvantaged farmers and ranchers of the role that new technologies will play in addressing challenges that face global agriculture (NIFA).
- Expand access to new knowledge and technologies for stakeholders through education and extension (NIFA).

Support international economic development and build capacity in trade-related activity through technical assistance (ARS, ERS, NASS, NIFA).

Actionable items

- Provide technical assistance to support the development of improved food security information and monitoring systems (ERS, NASS).
- Engage in capacity building activities with trading partners and R&D partners through collaborative research and other appropriate technical assistance programs to address specific trade issues and provide relevant scientific information on biotechnology and climate change, and scientific options for addressing researchable problems that would ensure food security (ERS).

Evaluate the U.S. food and agriculture sector's economic performance in globalized markets. Key emphasis areas include issues considered by the World Trade Organization (WTO), domestic policy reforms, and the structure and performance of agricultural commodity markets.

Actionable items

- Provide research-based information that will be the basis for decision-makers regarding tariff and non-tariff barriers to U.S. agricultural exports in major and in new markets (ERS).
- Assess international trends in food demand in different markets by developing measures of how countries respond to changes in price and income (ERS).
- Analyze firm characteristics in the U.S. food industry to determine how their influence on trade competitiveness will allow policy makers to better structure policies and programs (ERS).
- Investigate the impacts of trade policy reform and globalization on food processing firms and the effects of trade on productivity and employment in U.S. food industries (ERS).
- Determine how domestic support policies in foreign countries affect U.S. agricultural and food exports (ERS).

GOAL 9. Food Safety

CHALLENGE: The production, processing, and distribution system for food in the U.S. is a diverse, extensive, and easily accessible system. This open system is vulnerable to the introduction of contaminants through natural processes and global commerce, and by intentional means. Thus, the food supply must be protected from pathogens, toxins, and chemical

contamination that cause disease in humans. Outbreaks of *Escherichia coli* O157:H7 and *Salmonella* have attracted major media attention and drawn criticism of current food safety practices and policies. The Center for Disease Control and Prevention estimates that there are 48 million food-borne illnesses annually in the United States, resulting in approximately 128,000 hospitalizations and 3,000 deaths. While estimates of the economic burden vary widely, it is clear that the burden is significant, and potentially as large as \$6 billion annually, including lost productivity and loss of life. Food safety research requires the food chain to be treated holistically because hazards can enter the chain at any point. An integrated approach should consider food safety as a continuous process from production, through harvesting and processing, to retail and the consumer.

REE ROLE: Provide science that informs decisions and policies that contribute to a safe food supply and the reduction of food-borne pathogens.

STRATEGIES AND ACTIONS:

Provide research that helps to understand and define the microbial populations (pathogens and normal flora) in foods and surrounding environments.

Actionable items

- Develop approaches/designs for the analysis and interpretation of complex data (ARS, NIFA, ERS).
- Develop approaches/designs for both microbial and population-based studies, monitoring of emerging pathogens, and supplying data for identified data gaps (ARS, NIFA, ERS).
- Develop approaches that will evaluate the impact of intervention or management strategies on microbial contamination in the food continuum. This includes organic, conventional, and other production systems at all levels (small, medium, and large operations) as well as alternative harvest, processing, and marketing methods (ARS, NIFA, ERS).

Provide research to understand the biology and behavior of food-borne pathogens.

Actionable items

- Develop specialized technologies, for example, to differentiate pathogenic from non-pathogenic strains, and to elucidate the differences between pathogens and non-pathogens (ARS, NIFA).
- Develop a comprehensive microbial database containing molecular, physiological, and genetic data on each food-borne pathogen and their niche (ARS).
- Understand the outcomes from food-borne illness, including severity and impact on medical costs, lost work productivity, and loss of life (economic burden) (ERS).
- Provide relevant data to regulatory agencies for use in Hazard Analysis and Critical Control Points programs, risk assessments, labeling, persistence, and issues relative to international trade (ERS, NIFA).
- Develop model systems that have a utility for use in risk assessment (ARS).

Develop technologies for the detection and characterization of food supply contamination from microbial pathogens, toxins, chemicals, and biologics.

Actionable items

- Develop detection technologies for emerging or multiple microbial pathogens that are cost effective and provide the required informational detail for the determination and implementation of subsequent actions (ARS, NIFA).
- Develop technologies for the rapid and sensitive detection of toxins, chemicals, and biologics that can be implemented for improved food safety and food defense (ARS, NIFA).
- Develop multi-task, real-time, on/in-line inspection technologies that detect contaminants and quality attributes simultaneously at required line speeds (ARS, NIFA).
- Develop technologies for assessing the efficacy of various processing methods to reduce or eliminate the toxicity in contaminated foods for human/animal consumption (ARS, NIFA).

Develop intervention and control strategies for food-borne contaminants along the food production continuum.

Actionable items

- Determine the critical control points in production and processing that can be mitigated through the development and implementation of intervention and control strategies (ARS, NIFA).
- Determine the role/effect of transportation, lairage, slaughter, harvesting, processing methods, storage, and equipment on pathogen survival, growth, and transfer (ARS, NIFA).
- Develop mechanisms and approaches to evaluate and validate the effect of intervention and control strategies on food safety (ARS).
- Develop the economic models and statistical data to understand how interventions might be adopted and used by various agricultural production systems (ERS, NASS).
- Develop economically viable control and mitigation strategies, taking advantage of environmental, vector, and reservoir characteristics (ERS, NIFA, ARS).
- Provide outreach to producers and processors on intervention and control strategies, tailored to the risks associated and the specific audience (NIFA).

Address the food safety research, education, and outreach food safety priorities, as identified by the President's Food Safety Working Group.

Actionable items

- NIFA RFA integrates education and extension efforts that parallel food safety priorities (NIFA).
- NIFA RFA and ARS portfolio reflect research agenda priorities and complement perspective strengths (NIFA, ARS).
- Expand the Food Safety Information Center to provide information for food safety research projects, technical reviews, and education and training materials (ARS).
- Develop extension and educational strategies that transfer food safety information to our various REE stakeholders (NIFA).

Provide research strategies, models, and data that identify and characterize effective management strategies and incentives for food safety improvement and the costs and benefits of improved safety for public health and industry viability.

Actionable items

- Update and extend economic burden estimates (ERS).
- Identify incentives for food safety investment in meat and poultry plants (ERS).
- Identify on-farm food safety practices and incentives, through education and extension outreach (ARS, NIFA, ERS).

GOAL 10. Nutrition and Childhood Obesity

CHALLENGE: Childhood obesity has more than tripled and adult obesity has doubled in the past 30 years. The prevalence of obesity among children aged 6 to 11 years increased from 6.5% in 1980 to 19.6% in 2008. The prevalence of obesity among adolescents aged 12 to 19 years increased from 5.0% to 18.1% (CDC). At the same time, many sub-populations, including low-income and elderly populations, suffer from food insecurity, do not have adequate micronutrients, or face limited access to healthy food choices. Obesity in itself is a complex issue with no simple solution or answer. Preventative nutrition and physical activity strategies proven to be efficacious are required to reduce the incidence and prevalence of obesity and related chronic diseases and thereby lower health care costs. Elimination of malnutrition will also be a significant challenge. Establishing a balance of food availability and adequate nutrition will only be accomplished by changing not only the food supply and the environment, but also behaviors. This challenge will require research, monitoring, program evaluation, and translational activities to be conducted on a substantial scale in order to produce reliable results that can inform policies, nutrition assistance programming, and education/extension programs.

REE ROLE: Build the evidence base for food-based and physical activity strategies and develop effective education/extension translational activities to promote health and reduce malnutrition and obesity in children and high-risk populations.

STRATEGIES AND ACTIONS:

Link food systems to human health outcomes in the U.S. and internationally.

Actionable items

- Enhance the health-promoting quality of the food supply by connecting food production with human health outcomes (ARS).
- Determine the availability and affordability of food for American consumers, including the impact of USDA food assistance (ERS).
- Identify the economic determinants of food choices, including the impact of policies to improve diets (ERS).
- Improve knowledge of positive impacts of traditional diets on native populations.

Conduct nutrition monitoring of the American population and evaluate policies influencing nutritional health.

Actionable items

- Determine food purchase, food/nutrient consumption, and dietary patterns of Americans (ARS, ERS).
- Determine food purchase, food/nutrient consumption, and dietary patterns of “at-risk” populations in the U.S. (ERS, ARS)
- Compile and provide U.S. food composition data for essential nutrients and biologically active food components (ARS).
- Conduct analyses of the benefits and costs of policies to change behavior in order to improve diet and health, including nutrition education, labeling, advertising, taxes and subsidies, and regulation (ERS).

Build the scientific basis for dietary guidance for health promotion and disease prevention across the lifecycle.

Actionable items

- Identify the roles of foods, nutrients, dietary patterns, and physical activity in promoting health and preventing disease across the lifecycle (ARS, NIFA).
- Build the scientific evidence base for updating national dietary standards and guidelines (ARS).
- Determine mechanisms, such as genetic and epigenetic factors, by which nutrition promotes healthy development and function from conception to old age (ARS).

Develop and extend approaches to prevent obesity and related diseases.

Actionable items

- Determine the causes and consequences of obesity and related disorders (ARS, NIFA).
- Develop, evaluate, and support the implementation of viable strategies for changes in food environments and behaviors to encourage healthy food choices and prevent obesity and related diseases at the individual and community levels (ERS, ARS, NIFA).
- Evaluate the effectiveness of the *Dietary Guidelines for Americans* (DGA) and nutrition education programs built upon the DGA in preventing obesity and promoting health (ARS, NIFA).
- Improve and evaluate the effectiveness of existing educational programs to elevate the health of low-income families and youth through nutrition, physical activity, and food resource management (NIFA).

GOAL 11. The Fundamentals – Crop and Livestock Production

REE ROLE: REE provides the information, technologies, analysis, and capacity to enable the U.S. agriculture, food, and fiber systems to produce the food, fiber, and energy to meet growing and changing world demands for these products in an economically and environmentally sustainable manner.

STRATEGIES AND ACTIONS:

Invest in research, development, and outreach of new varieties and technologies to prevent animal/plant diseases and increase productivity, sustainability, and product quality (ARS, NIFA).

Actionable items

- Optimize integrated pest management practices for production crops by developing knowledge and tools for cultural methods, biological control, and host plant resistance management tactics.
- Develop and implement labor and cost saving technologies, such as remote sensing for biotic and abiotic stresses, spray application and fruit thinning technologies, and dynamic pre-harvest yield estimation to enhance production efficiencies for producers of all sizes.
- Develop livestock and aquaculture products and technologies with specific social and economic value to improve production efficiencies, product quality, animal health and animal well-being, and environmental performance. Continue development and application of genetic and genomic technology and sequence information to improve animal and plant production, reproduction, and quality.
- Improve ability to provide surveillance, early detection, rapid response, and appropriate recovery for emerging or reemerging plant and animal diseases of high consequence through the enhancement of national plant and animal disease diagnostic networks.
- Develop new varieties of crops and breeds/lines of livestock and aquaculture that consider nutritional content to enhance human health as a trait of primary importance, including more bioavailable vitamin and mineral content in new plant varieties and improved healthy fat profiles in animals.

Establish more sustainable systems that enhance crop and animal productivity and health (ARS, NIFA).

Actionable items

- Identify and implement best management practices for animal and plant systems that are environmentally, economically, and socially sound, including optimized tillage management strategies for key crops, optimized strategies for pollinator management and conservation, precision management practices for spatial application of water to maximize irrigation water use efficiency and increase profitability and recommendations for optimal cover crops and management practices to enhance carbon sequestration and soil health in no-till corn-soybean based rotations.
- Develop new management options to allow enhanced animal production systems to adapt to and/or mitigate biotic and abiotic stresses, such as aflatoxins, related to climate change.
- Integrate superior germplasm and best management practices into profitable, productive, and environmentally sound integrated systems for crop and animal production. Develop enhanced germplasm and superior production systems to lengthen the fresh market specialty crop harvest season to increase the nutritional value, availability, and affordability for local/regional markets.
- Develop more sustainable crop production systems for organic crops including producer guidance on N availability in organic systems and recommendations on

impact of crop rotation length and complexity on soil erosion control.

Improve feed use efficiency in animals (ARS, NIFA).

Actionable items

- Continue development and application of genetic, genomic, and other production technologies and alternative feed ingredients to improve nutrient utilization in livestock and aquaculture species and reduce environmental impacts.

Characterize and evaluate market performance and the provision of market information in domestic and international markets that affect producer decisions in agriculture's food, fiber, and energy sectors (ERS, NASS).

Actionable items

- Characterize and evaluate trends in agricultural research funding and direction, both public and private; the use of various funding instruments; and key factors affecting R&D and resultant productivity growth.
- Examine the critical factors affecting price levels, volatility, and price discovery in cash and futures market research.
- Conduct research on the U.S. food and agriculture sector's performance in increasingly globalized markets.

Provide statistical data for risk management and financial tools to farmers and ranchers (ERS, NASS).

Actionable items

- Deploy new small area sampling strategies that will not only provide a smaller, more targeted county estimate sample, but also allow coverage measures to describe county-level estimates.
- Evaluate trends and changes in production agriculture and adjust States included in U.S. market year average price calculations and States included in the county estimates statistics program accordingly.

GOAL 12. USDA Science is Recognized and Used

REE ROLE: Raise the visibility of USDA Science as the premier public institution for food and agriculture knowledge and technology. Its resources will be a key tool to help the Nation out-innovate, out-educate, and out-build the rest of the world.

STRATEGIES AND ACTIONS:

Inform the *scientific community* that USDA provides excellence in science to support a sustainable food and agriculture system for the U.S. (ARS, ERS, NASS, NIFA, FS, NRCS).

Actionable items

- Maintain an active role at OSTP, coordinated through OCS.
- Continue to strengthen relationships with NIH, NSF, etc. through coordination on projects with overlapping missions.

- Inform scientific societies of the accomplishments through USDA science. Provide each society with tailored information products.
- Develop a network of experts to facilitate agricultural research collaboration.
- Launch AAAS Eurekalert! agriculture portal tied to new REE web content.

Inform *USDA Science customers* of the impacts that USDA science and will continue to have on their productivity, profitability, and sustainability (ARS, ERS, NASS, NIFA).

Actionable items

- Provide customers with tailored reports on what USDA science is doing for them. They can use these in their magazines.
- Continue to have customer meetings seeking input and providing information on USDA science processes and outcomes.

Inform *stakeholders and State Departments of Agriculture* that we serve agriculture and food through science and that we will continue to be their partner in this grand endeavor (ARS, ERS, NASS, NIFA).

Actionable items

- Stakeholder meetings around roadmap.
- Coordinate travel with local ARS/RD/NRCS/FSA field offices to maximize exposure of USDA Science officials.
- Deliver key notes in non-traditional places.
- Develop a framework to gauge agricultural research activities and investments.
- Identify stakeholders meetings and coordinate with the Office of Congressional Relations.

Inform the *general public* of the contributions of USDA Science to their well-being and quality of life (ARS, ERS, NASS, NIFA, FS, NRCS).

Actionable items

- Launch USDA Science online magazine
- Press releases
- Big stories on USDA Science-work with DISCOVERY, Animal Planet, major news outlets, etc.
- Coordinate travel with local ARS/RD/NRCS/FSA/FS field offices to maximize exposure of USDA Science officials.
- Capitalize on the 150th Anniversary of the Department and Morrill Act by rolling out a campaign in support of agricultural science and education in 2012.
- Showcase USDA's history of scientific accomplishments through NAL rare and special collections.
- Connect main page of USDA Research and Science Link directly to REE. Clarify message on REE webpage.

Inform the *universities* that together we can create a new compact to build and sustain agricultural food systems for the United States (ARS, ERS, NASS, NIFA).

Actionable items

- OCS will do horizon scanning of agricultural science and assist in establishing national research priorities.

- Coordinate travel with local ARS/RD/NRCS/FSA field offices to maximize exposure of USDA Science officials.
- Coordinate travel to visit campuses and speak to students, faculty, and administrators about importance of science and opportunities for collaboration/partnership.
- Continue to partner with universities through ARS and reach out to provide assistance in the application process for NIFA grants for next year's RFAs (webinars, workshops, etc.)

Inform Congress of the long-term importance of supporting research that improves the well-being of their constituents and strengthens the global position of the U.S. (ARS, ERS, NASS, NIFA, NRCS, FS).

Actionable items

- Offer briefings to members and staff on developments in USDA science.
- Identify champions for agricultural research in authorizing and appropriating committees, as well as science and technology committees.
- Plan a strategy to circulate and garner recognition of the springtime report of the NAREEE Board.
- Continue to update Congress on USDA's science developments and reports through distribution of press releases, letters to delegations when scientific breakthroughs are made, or major news outlets have picked up stories.

IV. Implementation – Measuring Success

What is our measure of success? What identifies the success of this Action Plan? And what identifies success of science in the USDA? Success will depend upon the answers to three questions:

- (1) Is the Action Plan implemented?
- (2) Do the implementation steps accomplish their expected or desired results?
- (3) Do those results, in turn, accomplish the overall goal of the Action Plan, which is to improve the quality, effectiveness, and visibility of USDA science?

Having defined grand challenges and goals for USDA science, responsible governance requires that some form of accountability be established to determine if those challenges are being met, how well they're being met, and if the resources being used to achieve these goals are being used in the most efficient manner possible. That also begs the difficult question of how to attribute improvements in some grand goal to the science that was designed to support it. For example, an overarching goal of public policy is to enhance economic welfare of rural Americans. How do we link USDA research on, for example, plant breeding to improved economic welfare? Linking science endeavors to desired outcomes is a strategic process, and attempting to make those connections raises some useful considerations about the nature of the science undertaken.

Addressing the challenges defined in the REE Assessment and Action Plan is critical to developing and understanding the science that will be necessary to promote agricultural sustainability. Accountability is necessary to determine if we're moving science in the right direction—are we making the world better with our science? The challenges on the road ahead are grand and complex and will therefore be hard to observe whether they're being met.

The first step towards success has already occurred: goal teams that cut across the four agencies of the REE mission area developed the strategies and actions contained herein. As implementation of the Action Plan progresses, it will be important to assess whether or not the expected changes have resulted in desired outcomes. For example, does the increased collaboration lead to better integration of functions and disciplines; does the communication plan lead to more informed stakeholders; do the professional staff development activities result in a workforce that is better informed and more able to communicate USDA's unique role; and do the recruiting and mentoring activities lead to a larger and more diverse pool of qualified applicants? Outcome measures might include some of the same factors that are provided earlier in this document as evidence of the need for these action steps, for example, allocation of investments or characteristics of the workforce. Rather than propose specific measures here, however, each goal team or agency component that is charged with implementing an action step will develop a clear expected outcome and associated measures of success.

V. Closing Comments

The goals, strategies, and actions presented in this plan emphasize the cultivation of science-based evidence for decision-makers and end-users alike. Impact-driven agricultural science is critical to the future of agricultural and related industries in the U.S. The success of the action plan and the transformation of USDA into a high-profile research organization is dependent upon efficient use of research and educational resources and on continued support and resources from Congress.

This document is a work-in-progress that will evolve over time without straying far from the general themes. It will be evaluated periodically and adapted as necessary to reflect progress, shifts in priority, and adjustments in funding. Regular, frequent progress checks will be made within the mission area, and on an agency level, for specific actions. It is through ongoing stakeholder dialogue that we will maintain a culture of relevance. It is through our outcomes that the R&D return on investment can be measured.

It is expected that individual agencies within the mission area will refer to this document when drafting and refining their specific agency action plans. They will use it as a touchstone to guide them as they do their part to help America win in the global marketplace and strengthen our economy. By aligning with various components of the REE plan, specific agencies can and will demonstrate that their programs support the stated REE goals, which in turn support the broader Departmental goals set forth by the Secretary of Agriculture. Accomplishing the goals set forth in this document requires acceptance and support from the REE mission area, the agencies, and their employees. In part, accountability for progress made towards achieving these goals will occur via insertion of key items into senior-level REE mission area and agency performance plans. Establishing written, agreed upon, and reasonable goals in performance plans roots the goals and strategies within each agency and re-affirms their importance.