USDA Agricultural Research Service

Sustainable Agricultural Systems National Program 216 Action Plan 2023-2027

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Mission Statement

The mission of National Program (NP) 216, Sustainable Agricultural Systems, is to deliver scientific solutions that improve the holistic sustainability of U.S. agricultural and food systems and to design new systems that will be sustainable well into the future. Holistic sustainability includes food and nutrition security for all people, profitability for people employed in the agricultural sector, environmental health of agricultural landscapes, and quality of life for rural populations and society.

Vision Statement

Diversified agricultural systems that sustain and improve productivity, profitability, ecosystem health, and human well-being.

Relationship of NP216 to the USDA Strategic Plan for Fiscal Years 2022-2026

NP216 contributes primarily to USDA Strategic Goals 1: Combat Climate Change to Support America's Working Lands, Natural Resources, and Communities; 2: Ensure America's Agricultural System is Equitable, Resilient, and Prosperous; and 3: Foster an Equitable and Competitive Marketplace for All Agricultural Producers, through research related to the following objectives:

Objective 1.1—Use Climate-Smart Management and Sound Science to Enhance the Health and Productivity of Agricultural Lands

Objective 1.2—Lead Efforts to Adapt to the Consequences of Climate Change in Agriculture and Forestry

Objective 1.4—Increase Carbon Sequestration, Reduce Greenhouse Gas Emissions, and Create Economic Opportunities (and Develop Low-Carbon Energy Solutions)

Objective 2.2—Build Resilient Food Systems, Infrastructure, and Supply Chain

Objective 3.1—Foster Sustainable Economic Growth by Promoting Innovation, Building Resilience to Climate Change, and Expanding Renewable Energy

NP216 also provides support for USDA Strategic Goal 4: Provide All Americans Safe, Nutritious Food and 5: Expand Opportunities for Economic Development and Improve Quality of Life in Rural and Tribal Communities, by promoting production of safe and nutritious food and equitable improvement in quality of life in agricultural communities.

Relationship of NP216 to REE's USDA Science Blueprint (2020-2025)

USDA's Research, Education, and Economics (REE) mission area is currently updating this blueprint. NP216 contributes to:

Theme 1—Sustainable Agriculture Intensification (Plant Production, Animal Production)

Theme 2—Agricultural Climate Adaptation (Landscape-Scale Conservation and Management, Climate Research and Resiliency)

Relationship of NP216 to the ARS 2018-2020 Strategic Plan

ARS is currently updating this strategic plan to align with the new USDA and REE strategic plans. NP216 can be mapped to the most recently published (2018-2020) strategic plan, for which it contributes primarily to Research Goal Area 2: Natural Resources and Sustainable Agricultural Systems, especially Goal 2.4—Integrated Solutions for Agriculture Enabling Greater Productivity, Profitability, and Natural Resource Enhancement.

Relationship of NP216 to the United Nations Sustainable Development Goals (SDGs)

NP216 contributes primarily to SDG 2—End hunger, achieve food security and improved nutrition and promote sustainable agriculture and SDG 13—Take urgent action to combat climate change and its impacts.

Introduction

According to U.S. legal definition, the term "sustainable agriculture" means an integrated system of plant and animal production practices having a site-specific application that will, over the long-term—(A) satisfy human food and fiber needs; (B) enhance environmental quality and the natural resource base upon which the agriculture economy depends; (C) make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls; (D) sustain the economic viability of farm operations; and (E) enhance the quality of life for farmers and society as a whole (7 USC § 3103(19)). Improving an agricultural system's sustainability involves enhancing all five of these functions simultaneously while understanding that there will be tradeoffs between them, and empowering people to make informed decisions about the functions that they value most. An agricultural system can be viewed from multiple perspectives, including a whole-farm system, a landscape agroecosystem, and the communities that these are located in. The United States has a wide diversity of agricultural systems and research to improve their sustainability requires the combined creative efforts of transdisciplinary teams.

This new action plan for NP216 was developed based on stakeholder input received from about 150 people during 12 listening sessions in April and May of 2022. Stakeholders included farmers and ranchers, university collaborators, other government agencies, conservation organizations, and private sector partners with sustainability goals. A special effort was made to reach out to minority farmers and ranchers, organizations from underserved communities, and minority-serving educational institutions during these sessions.

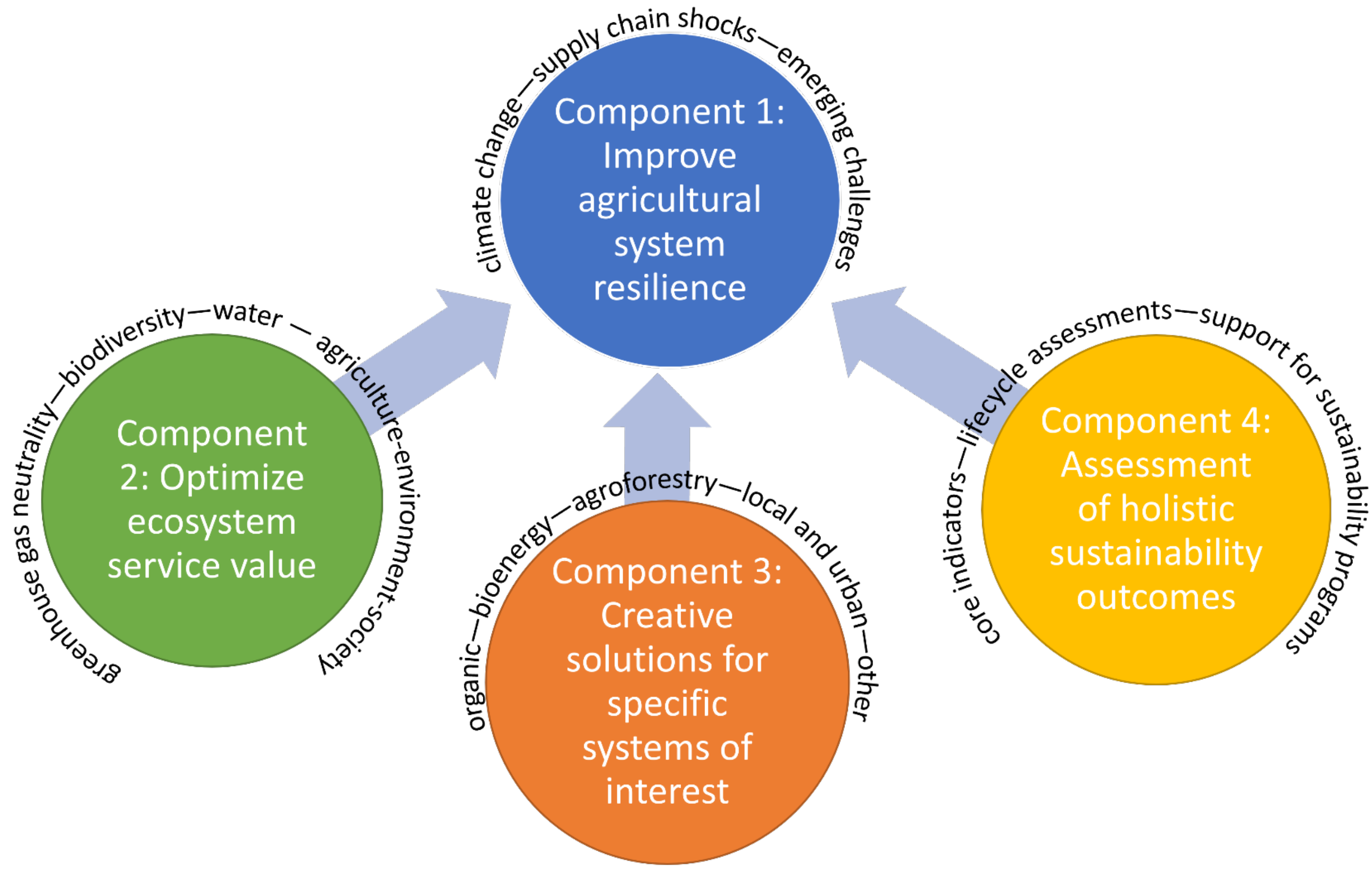
This new action plan builds on the goals of the previous action plan (2018-2022). The previous plan focused on using an analysis of genetics x environment x management (GxExM) to build more intensive, resilient production systems. Genetic improvement of plants and animals is covered by other ARS national programs (NP301—Plant Genetic Resources, Genomics, and Genetic Improvement; NP101—Food Animal Production), and the role of NP216 is to discover how to optimize the performance of these improved genetic resources through environment-specific farm management practices. Because it is not possible to test every management option on every crop variety or animal breed in every environment, an important aspect of NP216 is using experimental data to build models that can predict which management and genetic options are most likely to succeed in specific and ever-changing environments. In the new action plan, the focus has evolved to prioritize system resilience, where the resilience of both productivity and other ecosystem services are emphasized. The previous 2018-2022 action plan had a focus on increasing production efficiencies, which has been enhanced in this plan to establish a clear focus on resilience to supply chain shocks – such as shocks currently caused by pandemics and global conflicts. However, supply chain shocks may arise due to other causes (e.g., economic downturns and other international events), so this focus allows for this national program to address shocks as they arise. Similarly, the previous plan's focus on achieving agroecosystem production potential has shifted to quantifying multiple goals of sustainability through core indicators, using a systems perspective to enable understanding of tradeoffs and synergies.

A new focus on specialized agricultural systems such as organic, bioenergy, agroforestry, and local and urban food systems has been added in this action plan because these topics were frequently emphasized by stakeholders during listening sessions. There has been steady research on these topics in

NP216 and other national programs over the years, and they can be found in historical action plans, but they were not explicitly mentioned in the 2018-2022 plan. Stakeholders are specifically interested in seeing the sustainability strategies that have been studied in large-scale commodity systems translated for more specialized systems, which are often smaller scale.

Due to the multidisciplinary nature of systems research, NP216 is integrally involved in several research and outreach networks. Ten of the 18 Long-Term Agroecosystem Research (LTAR) network sites have NP216 projects, and all four components of NP216 are well-aligned with the 2015 Shared Research Strategy and the new LTAR strategy document that is currently in development. ARS partners with the USDA Climate Hubs network as it seeks to understand the climate adaptation needs of stakeholders and translate research findings into usable information. Five of the 10 regional climate hubs have NP216 projects directly associated with the Hub and many other NP216 projects are designed in collaboration with their partner Hub. NP216 researchers are involved in developing strategies for helping farmers and ranchers adapt to changing weather patterns (especially those contributing to Problem Statement (PS) 1A: Resilience to changing climate trends and extreme weather) and in designing agricultural systems that mitigate greenhouse gas emissions and provide nature-based carbon storage solutions (especially PS 2A: Greenhouse-gas-neutral agricultural systems), including participation in long-term data collection through the Greenhouse-gas Reduction through Agricultural Carbon Enhancement network (GRACEnet), which was initiated in the early 2000s.

NP216 Research Components



Component 1: Improve agricultural system resilience

- 1A: Resilience to changing climate trends and extreme weather
- 1B: Resilience to supply chain shocks
- 1C: Resilience to emerging and persistent challenges

Component 2: Optimize agricultural systems to increase ecosystem service value to farmers and society

- 2A: Greenhouse-gas (GHG) neutral agricultural systems
- 2B: Biodiversity
- 2C: Water availability and quality
- 2D: Agriculture-environment-society nexus

Component 3: Design creative solutions for enhancing the sustainability of targeted and often small-scale agriculture and food systems

- 3A: Organic systems
- 3B: Bioenergy systems
- 3C: Agroforestry systems
- 3D: Local and urban food systems
- 3E: Other systems of interest

Component 4: Enable assessment of holistic sustainability outcomes of U.S. agricultural systems

- 4A: Enable system comparison using core indicators
- 4B: Enable agricultural process and product evaluation
- 4C: Enable assessment of agriculture and natural resource sustainability programs

Component 1: Improve agricultural system resilience

In the coming decades, it will be increasingly important for agricultural systems to have sufficient stability and diversity that together enable the farming enterprise and the agroecosystem to be productive and resilient, and when necessary, recover from and adjust to serious disruptions and difficulties. Disruptions will likely include changing weather patterns, rising costs of agricultural inputs, and emerging threats (such as herbicide-resistant weeds and potential contamination with undesirable chemicals, including but not limited to polyfluorinated alkyl substances (PFAS) and microplastics), in addition to persistent and emerging challenges related to pests, diseases, and other stresses. It will be important for farmers and ranchers to have tools to forecast these disruptions as accurately as possible so that they can adapt to predictable challenges and develop strategic system redundancies to enable recovery. Research will support this resilience goal by testing both incremental improvements that could be implemented immediately and innovative systems that will enable long-term transitions for future conditions.

Problem Statement 1A: Resilience to changing climate trends and extreme weather

As climate trends shift, U.S. farmers and ranchers are experiencing incremental long-term trends including shifts in frost dates or chill hours, shifts in rainfall patterns resulting in wetter springs and drier, hotter summers, and increasing and potentially debilitating limitations in irrigation water availability. They are also experiencing extreme weather events like floods, hurricanes, derechos, and multi-year droughts. As the National Weather Service and the National Oceanic and Atmospheric Administration (NOAA) continue to improve short- and medium-range weather forecasts, ARS will develop models to predict the effects of these forecasts on agricultural system performance and collaborate with end users to develop tools that enable better adaptation strategy planning. These adaptation strategies may include crop variety and animal breed selection changes, management of cropping and animal systems to optimize available resources, and risk reduction through diversification in both time and space.

Research Focus

ARS scientists will:

1) identify the most important weather-related resilience challenges faced by farmers and ranchers;
2) design and test new management systems using plant and animal genetics that maintain reliable productivity under variable weather ;
3) develop, optimize, and use models to predict which plant and animal genetics and farm management techniques will provide the most reliability under predicted short-, medium-, and long-term weather variations; and
4) develop or improve decision support tools for early detection and mitigation of stress from changing weather conditions.

Anticipated Products

- Recommendations and improved decision support tools for farmers and ranchers as they make seasonal management decisions about sowing and harvesting dates, genetics, crop and animal nutrition, and water management
- Improved crop and system models that can be used with weather predictions at multiple time scales

- Authoritative experimental data sets that can be used by systems modelers to address knowledge gaps and reduce uncertainty
- Novel diversified agricultural systems designed for resilience to weather-related challenges
- Tools for detection of early plant stress symptoms and identification of plant phenotype associated with climate resilience for breeding programs

Potential Benefits

- Crop advisors and extension professionals have access to tools that help them provide timely information for system management decisions.
- The USDA Climate Hubs will be provided with data and information to create and enhance their tools that assist regional producers in managing their production systems to be more resilient to climate change and extreme weather challenges.
- Plant breeders have access to tools that help them make selections for climate resilience of cash crops and cover crops.
- Farmers and ranchers adapt their management systems and maintain economic viability as weather variability increases.
- Sufficient quantities of affordable, nutritious food and other agricultural products are produced annually despite weather extremes.

Problem Statement 1B: Resilience to supply chain shocks

In recent months, farmers and ranchers have experienced sudden and dramatic shocks to input costs because of supply chain issues that are entirely out of their control, including COVID-19 pandemic disruptions of food processing and distribution systems and sharp increases in fuel and fertilizer costs due to armed conflict in global regions of strategic importance to fossil fuel and fertilizer production. One approach to improving resilience to supply chain shocks is increasing input use efficiency, often through precision agriculture techniques. Another complementary approach is to diversify input sources, such as exploring innovative fertilizers and improving manureshed management to optimize reuse of manure nutrients.

Research Focus

ARS scientists will:

1) design and test technology and management practices that improve input-use efficiency, including water, nutrients, fuel, labor, agrichemicals, and
2) explore the use of alternative sources or types of inputs, including rainwater harvesting, alternative fertilizers and fuels, and robotics.

Anticipated Products

- More efficient precision agriculture techniques at resolutions appropriate to farm size
- Data about effectiveness and sustainability of alternative sources or types of inputs needed for agricultural productivity and sustainability
- Data and tools for access to and selection of alternative inputs (when traditional inputs are limited due to supply chain issues) for maintaining agricultural system operations

Potential Benefits

- Farmers and ranchers use traditional inputs more efficiently, enabling them to maintain productivity even if supply chain shocks occur.
- Farmers and ranchers have diversified options for obtaining input supplies in case of supply chain disruption.

Problem Statement 1C: Resilience to emerging and persistent challenges

Two of the emerging agricultural system challenges are the increasing prevalence of herbicide-resistant weeds, which threaten crop yields and the feasibility of implementing conservation tillage, and the uncertainty around the concentration of contaminants of concern, including but not limited to polyfluorinated alkyl substances (PFAS) and microplastics that have been found in some farming systems due to contamination of soil or water sources. There are also persistent biotic and abiotic stresses that continue to challenge our ability to sustainably manage agricultural systems. One important way to increase resilience to these threats is to improve our ability to detect them accurately, followed by development of innovative techniques for managing or adapting to these threats.

Research Focus

ARS scientists will:

1) develop or improve detection methods for emerging and persistent resilience threats, and
2) develop and test farm management strategies to prevent and mitigate damage from these stresses.

Anticipated Products

- Decision support system for predicting the probability of pest (including weed) occurrence, detecting, assessing severity, and implementing mitigation strategies
- Tools for detection and mitigation of PFAS contamination in agricultural systems and products
- Tools for detection and mitigation of microplastics contamination in agricultural systems and products
- Recommendations for addressing herbicide-resistant weed control in cropping systems
- Recommendations for limiting yield loss from emerging crop pathogens through cropping system management techniques
- Strategies such as soil amendments, seed coatings, and irrigation control for reducing aflatoxins
- Identification of sources and mechanisms of abiotic and biotic stress resilience in crops

Potential Benefits

- The USDA Climate Hubs will be provided with data and information for helping their producers proactively manage their systems to climate related emerging and/or persistent challenges.
- Farmers and ranchers have multiple options for controlling herbicide resistant weeds, which will prevent their spread and mitigate their negative impacts.
- Farmers and ranchers have farming system management options for reducing yield loss from pathogens and insect pests, leading to greater productivity.

- Plant breeders have tools for enhancing selections for stress resilience in varietal development programs, leading to increased resilience of new varieties.
- Lower levels of aflatoxin and PFAS and microplastics will prevent economic loss to the producer and mitigate human and animal health risks.

Component 1 Resources

Akron, Colorado	Ames, Iowa	Auburn, Alabama
Beltsville, Maryland	Burlington, Vermont	Columbia, Missouri
Corvallis, Oregon	Dawson, Georgia	Las Cruces, New Mexico
Lincoln, Nebraska	Mandan, North Dakota	Mississippi State, Mississippi
Orono, Maine	Pendleton, Oregon	Raleigh, North Carolina
Salinas, California	Sidney, Montana	Stoneville, Mississippi
Temple, Texas	Tifton, Georgia	University Park, Pennsylvania
West Lafayette, Indiana		

Component 2: Optimize agricultural systems to increase ecosystem service value to farmers and society

The most easily recognizable ecosystem service of any agroecosystem is the provisioning of food, feed, fiber, fuel, or other agricultural products. Agroecosystems also provide other beneficial ecosystem services, including some that society is developing mechanisms to pay producers for, such as carbon sequestration, biodiversity, and water quality and quantity. It is important for farmers and ranchers to be able to manage agricultural systems for their agricultural productivity goals as well as participating in current and developing ecosystem service markets. In addition to marketable services, agroecosystems provide other ecosystem services that are not yet easily marketable, including diverse cultural services. It is important for producers and society to understand the value of these services as well. Soil health is frequently considered to be foundational for most if not all ecosystem services and strategies for improving soil health will also provide the co-benefits of enhancing the value of these other ecosystem services.

Problem Statement 2A: Greenhouse-gas (GHG) neutral agricultural systems

One complex factor affecting agriculture is related to climate change and the connection of climate change impacts to greenhouse gas emission dynamics. As agriculture is identified as one of the enterprises contributing to greenhouse gas emissions (as well as being an enterprise that can lead to the abatement of greenhouse gas issues), this national program has been charged by its stakeholders to conduct advanced research to improve these dynamics. Many entities have communicated a goal for having sectors of society become “greenhouse-gas neutral,” meaning that although there will continue to be some greenhouse gas emissions as part of healthy agricultural systems, there will be at least an equivalent amount of carbon removed from the atmosphere and stored in these systems. Achieving greenhouse-gas-neutral agricultural systems in the United States will require major advances in storing stable carbon in agricultural landscapes and decreasing emissions of methane and nitrous oxide from agricultural systems. According to the EPA national greenhouse gas inventory in 2019, agricultural systems emitted nearly 20 times more greenhouse gases, primarily nitrous oxide and methane, than the carbon stored in croplands and grazing lands. To achieve neutrality, we need to do the following: 1) improve our ability to account accurately for C storage and GHG emissions at farm- and national-level; 2) increase the amount of carbon that can be stored long-term above- and below-ground in agricultural landscapes; 3) decrease methane emissions from ruminant animals and rice fields while capturing manure-source methane as biogas; and 4) decrease nitrous oxide emissions from nutrients applied to croplands without increasing other forms of nitrogen pollution. Some organizations that want to improve the carbon footprint of their supply chains pay farmers per acre to reduce emissions or provide long-term carbon storage.

Research Focus

ARS scientists will:

1) develop new and improve existing methods for quantifying carbon storage and greenhouse gas emissions from agricultural systems (including direct measurement and modeling);
2) contribute to a national monitoring network by collecting data on the effects of GHG mitigation practices across many environments;

3) design and test the effects of system management options on carbon storage and GHG mitigation; and
4) explore novel techniques for long-term carbon storage and mitigation of methane and nitrous oxide emissions from crop and livestock systems.

Anticipated Products

- Agricultural system analysis methods and tools to identify important GHG emissions sources and prioritize mitigation strategies
- Scientifically rigorous methods for evaluating long-term carbon storage capacity of soils
- Publicly accessible data sets quantifying how much carbon can be stored from recommended management practices under different conditions
- Publicly accessible authoritative data sets quantifying GHG emissions resulting from plant or animal production, but that also include impacts of disease, extreme weather events, and other critical factors affecting these production systems that can influence GHG emissions differentially
- Information for producers (especially small- and medium-scale) on options for engaging with carbon market initiatives
- Recommendations for producers to incorporate trees and woody species in their landscapes to improve system productivity (via the co-benefits of these added species) and carbon storage

Potential Benefits

- Farmers, ranchers, and government agencies can predict which carbon storage and GHG mitigation techniques are likely to have the most significant impact on achieving greenhouse-gas-neutral agricultural systems.
- Government agencies, ecosystem service markets, and other stakeholders will have accurate and affordable methods to test the effects of a variety of interventions on net greenhouse-gas emission or carbon sequestration.
- Farmers and ranchers will have multiple options for participating in carbon markets and making progress towards greenhouse gas neutrality.
- Policy makers will have sufficient data to guide policy decisions about how to incentivize carbon-positive agricultural production.
- The U.S. agriculture sector will make progress towards greenhouse-gas-neutrality, enabling the United States to continue contributing to global food and nutrition security without exacerbating climate change.

Problem Statement 2B: Biodiversity

Agroecosystems tend to have lower biodiversity than natural ecosystems because producers encourage the growth of a few species of plants or animals (e.g., monocropping, or limited crop rotations). Agroecosystems can, however, be managed to increase functional biodiversity in the production system, including increases in soil microbial and macrobial diversity (which often leads to greater soil health, carbon sequestration, and water infiltration/retention and nutrient retention dynamics) and beneficial plants and insects, while retaining the provisioning services of the production system. Improving biodiversity benefits both producers and society by providing greater system stability, increased water availability and quality, and improved pollinator and wildlife habitat, and enabling ecological pest control strategies. Some ecosystem service markets are developing biodiversity credits that can be stacked with carbon credits so that farmers receive extra support for improving biodiversity.

Research Focus

ARS scientists will:

1) develop new and improve existing methods of quantifying functional biodiversity ecosystem services (including pest control);
2) develop new and improve existing system management techniques for improving soil ecosystem community diversity and enhancing soil health; and
3) identify, improve, and design landscape management options for improving plant biodiversity and habitat for beneficial insects and important wildlife species without increasing pest problems.

Anticipated Products

- Recommendations for system management techniques that improve soil ecosystem diversity and the concomitant co-benefits of improved soil function and disease suppression
- Recommendations for landscape management that provides habitat for beneficial insects and wildlife

Potential Benefits

- Farmers and ranchers have multiple options for improving biodiversity and benefitting from engagement with ecosystem service markets.
- Improved biodiversity leads to increasing services from pollinators and other beneficial insects and better ecological pest control, reducing reliance on expensive inputs.
- Farmers have options for increasing revenue from recreational activities in more diverse landscapes.

Problem Statement 2C: Water availability and quality

The agricultural sector in the United States is a large user of freshwater supplies and has been a significant source of pollution for waterways. Society benefits when agroecosystems become more water efficient, as this enables more agricultural production and makes more water available for other uses. Society also benefits when agricultural systems implement practices that prevent pollution by minimizing soil erosion and nutrient (including both fertilizers and manure) run-off. Cleaner water means lower costs of water purification, better fishing, and fewer recreation days lost to harmful algal blooms. Ecosystem service markets are developing which enable society to pay farmers for implementing conservation practices, and it is important for all parties to know which practices are most effective and to be able to quantify their effects, while also maintaining system productivity.

Research Focus

ARS scientists will:

1) investigate the additive benefits of action across multiple ecosystem services to inform stakeholders on options for participating in ecosystem service markets that pay farmers for stacked benefits;

2) develop new and improve existing methods for quantifying water quality and quantity services of agroecosystems; and
3) quantify the water quality and quantity benefits of changes in agricultural system management.

Anticipated Products

- Information for farmers and ranchers to make informed decisions about participation in ecosystem service markets that include payments for water quality and quantity benefits
- New or improved technical options for mitigating erosion and nutrient loss from agricultural systems
- Recommendations about mitigation options that will be most effective at improving water quality in certain situations
- Publicly accessible data sets quantifying the effects of water conservation techniques on water availability

Potential Benefits

- Water quality will improve (less eutrophication), soil erosion will be avoided, and water will be more equitably shared.
- Farmers and ranchers will be able to receive payments for practices that improve water quality or quantity in ecosystem service markets that stack benefits (e.g., providing payments for both carbon sequestration and water benefits).
- Ecosystem service markets will be able to quantify water quality and quantity benefits of improved agricultural system management.

Problem Statement 2D: Agriculture-environment-society nexus

Agroecosystems provide many other ecosystem services to farmers and society, including temperature and flood regulation, recreation, hunting opportunities, holistic benefits of sustainable systems, quality of life, and cultural services. These services are often difficult to quantify, and ecosystem service markets have yet to develop ways for society to pay farmers for these benefits. Identifying and developing ways of measuring these services will enable farmers to better quantify and communicate how production system management provides additional services to society. NP216 and its associated ARS Climate Hubs are uniquely poised to address these dynamics.

Research Focus

ARS scientists will:

1) assess the socioeconomic impacts of agricultural systems to identify production/environment/society trade-offs and co-benefits;
2) develop methods of quantifying diverse ecosystem services that are not (yet) directly marketable;
3) compare ecosystem services of alternative land use options; and
4) work with and through the ARS Climate Hubs to engage producers and stakeholders to address their priorities at this nexus.

Anticipated Products

- Ecosystem services optimization tools that can be used to support decision-making on land use and land management (e.g., to quantify the trade-offs between pollination service improvement due to pollinator plantings and the loss of direct production due to pollinator plantings)
- Publicly accessible data sets that quantify tradeoffs in ecosystem services when agricultural systems are managed differently
- Improved methods and tools for assessing socioeconomic impacts of changes in agricultural system management
- Enhanced ARS Climate Hub impact by broader connectivity across NP216 projects and stakeholders, to collect, assess, and optimize the utility of these dynamic intersecting priorities

Potential Benefits

- Farmers, ranchers, and land managers will have additional tools to enable them to make informed decisions about agricultural system management.
- Additional ecosystem services may become marketable.
- Policy makers will have additional data to inform their decisions about incentivizing agricultural system management techniques.

Component 2 Resources

Beltsville, Maryland
Corvallis, Oregon
Orono, Maine
Salinas, California
University Park, Pennsylvania
Burlington, Vermont
Lincoln, Nebraska
Pullman, Washington
Sidney, Montana
West Lafayette, Indiana
Corvallis, Oregon
Mandan, North Dakota
Raleigh, North Carolina
Stoneville, Mississippi

Component 3: Design creative solutions for enhancing the sustainability of targeted and often small-scale agriculture and food systems

All agricultural systems can be enhanced to regenerate agroecosystems through better utilization of on-farm resources, conservation practices that improve soil health, and adaptations that improve climate resilience. Many of these regenerative practices are labor- and knowledge-intensive. Efficiencies of scale and technology that are available to large-scale farming operations, however, are not as available to smaller operations. Furthermore, the concept of the "food system" expands on the agricultural system by including food processing, distribution, and consumption. The goal of optimized food systems is to provide sufficient quantities of healthy, desirable, and affordable food to enable all people to improve diet-related health. Research that improves the economic, environmental, and social sustainability of specialized production and for optimizing food systems at all scales will enable more sustainable food production and champion the important co-benefit of ensuring more equitable distribution of research benefits to underserved communities.

Problem Statement 3A: Organic systems

There are two primary drivers that emphasize the priority for enhancing the sustainability of U.S. organic management systems: 1) the gap in U.S. organic production compared to U.S. consumer demand for organic foods and 2) the need to ensure that organic systems are profitable and sustainable for organic producers and their communities. U.S. organic production opportunities are broad and diverse, and there is especially great potential for small and medium farms producing specialty crop and animal products to adopt organic practices. This is in part due to organic farming being more labor-intensive than conventional farming and therefore well-suited to higher-value products. Organic systems require special approaches to adopt soil health improvement practices that have become more common in conventional systems, such as cover cropping and reduced tillage. Integrated weed management is a high priority for organic producers. Owing to scale issues, it will likely be easier for small to medium farms to make a transition to implement organic management strategies, but the sustainability of such efforts needs research support to reduce uncertainties and minimize risks, to manage input costs and improve yields, to quantify and optimize the ecosystem benefits of organic production, and to assess and improve the sustainability (including economic viability, labor requirements, and social sustainability) of organic crop and livestock production systems.

Research Focus

ARS scientists will:

1) develop solutions for organic systems to improve productivity and resilience;
2) assess ecosystems services of organic systems and provide recommendations for enhancement; and
3) adapt precision management techniques for organic systems.

Anticipated Products

- Improved soil fertility recommendations for organic systems to mitigate the risks of nitrogen deficiency and excess phosphorus
- Recommendations and equipment for small-scale conservation tillage systems

- Recommendations for cover crop use in organic systems and equipment for mechanical termination
- Decision support tools for real time management options based on weather predictions
- Tool development to assist producers in the selection of optimal organic production systems and management approaches for their agroecosystem

Potential Benefits

- Organic producers have information and tools to improve productivity, profitability, and sustainability of organic crop and animal production systems.
- Consumers have a larger supply of domestically produced organic food.
- Consumers have information about the environmental footprint of organic food.
- Producers have information about which parts of their systems have the biggest ecosystem service risks and options for mitigating these risks.

Problem Statement 3B: Bioenergy systems

In the coming decades, there is likely to be a shift to a more circular bioeconomy and an increase in use of renewable fuels, including biofuels. As U.S. agricultural systems include innovative ways to use plant and animal waste products, it will be important that producers understand how to capitalize on the bioenergy potential of these systems while also meeting other production and sustainability goals. Bioenergy systems include lignocellulosic ethanol production from plant biomass (with corn grain ethanol systems as a standard for comparison), biodiesel production from oilseed crops (with petroleum-derived diesel as the comparison), biogas production from animal waste, and biochar and associated biofuel products made from a wide variety of feedstocks.

Research Focus

ARS scientists will:

1) design solutions for cropping systems which incorporate bioenergy crops, assessing their productivity, resilience, and sustainability;
2) develop and improve crop and farming system models for predicting best combinations of bioenergy crop varieties, environments, and management practices; and
3) develop and test solutions for biochar production and use in agricultural systems.

Anticipated Products

- Recommendations for sustainable production practices for bioenergy feedstocks, including strategic use of new germplasm in appropriate environments
- Decision support tools for farmers who want to add bioenergy crops to their rotations
- Assessment of environmental services of bioenergy feedstock production systems and options for enhancing their value
- Enhanced economic efficiency of biochar production at the regional level that optimizes consideration and implementation of feedstock sources, processing, distribution, and agricultural use
- Enhanced processing of biochar feedstocks to optimize approaches for economic utility of co-generated biofuels and biogases co-generated during biochar production, leading to greater economic viability for the biochar enterprise

Potential Benefits

- Farmers will be able to achieve higher yields of bioenergy feedstocks, leading to a more consistent supply for biofuel companies.
- Small-scale producers will have better access to bioenergy feedstock markets through mechanisms such as the development of cooperatives and supply chains.

Problem Statement 3C: Agroforestry systems

Increasing the number of trees in agricultural landscapes has the potential to move the agricultural sector towards greenhouse gas neutrality as well as providing benefits to the farm. Agroforestry includes silvopasture, forested riparian buffers, windbreaks to protect crops and livestock, alley cropping, and multi-story cropping. Because of the long lifespan of trees, it is important to consider future climate scenarios when establishing new trees in a landscape. Careful selection and management of the trees in agroforestry systems can provide income from the trees in addition to productivity benefits in crop and animal agriculture and a wide range of ecosystem services.

Research Focus

ARS scientists will:

1) design and test solutions for complex management challenges associated with trees in agricultural systems;
2) quantify system productivity, resilience, and ecosystem services of trees in agricultural landscapes;
3) include long-term agroforestry experiments as part of some Long-Term Agroecosystem Research (LTAR) network sites; and
4) add agroforestry practices to farming system models to support their inclusion in decision support tools.

Anticipated Products

- Recommendations for adding trees to crop and livestock systems to improve productivity and carbon storage
- Recommendations for managing timber harvest and replanting areas to include agricultural production
- Publicly accessible data sets quantifying productivity and other ecosystem services of trees incorporated in a wide variety of agricultural systems
- Methods and tools for quantifying benefits of trees and woody plants in agricultural systems
- Decision support tools for identifying tradeoffs of management options for agroforestry systems

Potential Benefits

- Farmers and ranchers have more options available for increasing productivity, resilience, and carbon storage by including trees or woody plants in agricultural systems.
- Producers and ecosystem service markets have methods for quantifying agroforestry system ecosystem services, leading to inclusion of agroforestry practices in ecosystem service markets.
- Government agencies have methods for quantifying carbon stored in trees outside of forests, leading to more accurate accounting of carbon in agricultural systems.

Problem Statement 3D: Local and urban food systems

The main goal of local and urban food systems is to make healthy food available to people in the places where they live. These systems include community gardens, indoor and vertical agriculture, farm-to-school systems, and other direct-to-consumer marketing arrangements. Because these food systems are not expected to supply large quantities of commodity goods, there are opportunities to improve urban-rural interactions by marketing sustainable agricultural practices. Enabling these specialized systems to serve their community requires improvements in all aspects of sustainability.

Research Focus

ARS scientists will:

1) develop food system models for understanding and comparing holistic sustainability outcomes of various food systems, including human health, human well-being, and environmental implications;
2) develop data collection and processing pipelines to support interaction between producers and consumers; and
3) investigate social factors affecting local and urban food system sustainability.

Anticipated Products

- Integrated food system models for predicting human health and environmental implications of food system changes
- Data systems that enable agricultural producers to understand consumer values as they engage in farm-to-fork programs
- Publicly accessible data sets quantifying sustainability outcomes of a wide variety of food system options, including both commodity-based systems with traditional supply chains and local or regional systems
- Framework for urban growers to assess soil health in their unique systems, such as an expansion of soil health tools to include urban production systems
- Recommendations for urban growers to improve the sustainability of their systems

Potential Benefits

- Producers will have more opportunities to engage effectively with local and urban consumers, leading to increased profitability and a better match between supply and demand.
- Urban growers will have greater access to tools and techniques for improving the sustainability of their production systems.
- Consumers will have improved access to affordable, nutritious food options.
- Policy makers will have access to data to make informed decisions about policies affecting food systems.

Problem Statement 3E: Other systems of interest

There are a wide variety of other agricultural systems mentioned during our stakeholder listening sessions, including agrivoltaics, aquaculture, ethnic specialty foods, insect-based proteins, and protected environments (e.g., high tunnels). Although NP216 does not yet have projects focused on these systems, we seek to collaborate with others, including other ARS national programs and university partners, to improve the sustainability of the entire system. We are interested in assessing ecosystem service benefits, system-level productivity, and social impacts of these systems.

Research Focus

ARS scientists will:

1) collaborate with other researchers, industry partners, and community organizations to evaluate the sustainability of other agricultural systems of interest, and
2) work with stakeholders to co-design solutions to improve the sustainability of these systems.

Anticipated Products

- Sustainability assessments of other agricultural systems of interest to stakeholders, leading to identification of priority areas for sustainability improvements and expanded ARS research efforts
- Novel solutions for improving the sustainability of these systems

Potential Benefits

- Co-designed sustainability solutions will be useful for agricultural system entrepreneurs as they seek to improve their systems.
- New areas of research will be identified for systematic future exploration.

Component 3 Resources

Ames, Iowa	Akron, Colorado	Auburn, Alabama
Beltsville, Maryland	Burlington, Vermont	Columbia, Missouri
Corvallis, Oregon	Mandan, North Dakota	Maricopa, Arizona
Orono, Maine	Raleigh, North Carolina	Salinas, California
Temple, Texas	Tifton, Georgia	

Component 4: Enable assessment of holistic sustainability outcomes of U.S. agricultural systems

Our main purpose in assessing the holistic sustainability outcomes of U.S. agricultural systems is to identify problematic trends so that we can implement solutions before they get worse. This type of assessment requires the selection and definition of key indicators of economic, environmental, and social sustainability which can be measured with scientific rigor across a wide variety of systems. There are many different stakeholder perspectives on which aspects of sustainability are the most important and how to improve them, so there are many potential users of these indicators. The role of ARS is to provide leadership in maintaining the scientific quality of these assessments and develop methods to improve their usefulness. The problem statement topic areas for this component describe different types of indicators for different stakeholders.

Problem Statement 4A: Enable system comparison using core indicators

Core indicators include consideration of all five domains of sustainable intensification as used by USAID Feed the Future. The domains include productivity, economic, environmental, human (individual), and social (groups of humans). The Long-Term Agroecosystem Research (LTAR) network seeks to use these domains to compare the sustainability of the business-as-usual and aspirational agricultural systems that have been identified with stakeholder input at each of the 18 locations. These core indicators can also be used to monitor sustainability trends of a particular agricultural system over time and identify which aspects of the system are working well and which could be improved.

Research Focus

ARS scientists will:

1) develop a set of core sustainability indicators that can be used in any agricultural system to evaluate environmental, economic, and social sustainability, and
2) compare popular and alternative agricultural systems across the United States to understand tradeoffs and trends over time.

Anticipated Products

- Standardized methods and protocols for core indicator assessment
- Authoritative data sets demonstrating the effects of alternative agricultural management techniques on environmental, economic, and social sustainability of U.S. agricultural systems
- Recommendations for agricultural system transitions to improve resilience

Potential Benefits

- Agricultural producers will have improved access to information about the benefits and risks associated with the adoption of best management practice recommendations.
- Scientists will have a framework for defining and assessing agricultural system sustainability.
- Civil society organizations and policy makers will be able to monitor sustainability trends over time and use this data to debate mitigation options for concerning trends.

Problem Statement 4B: Enable agricultural process and product evaluation

An important specialized use of sustainability assessment is to evaluate the sustainability of an agricultural process or product using life-cycle assessment (LCA). The goal of LCA is to assess the entire life cycle including preparation, production, marketing, maintenance, reuse, and disposal, often with respect to its carbon, water, or energy footprints. LCA is especially important for bioenergy systems, which aim to have a lower carbon footprint than fossil-fuel-based energy systems. An environmental product declaration (EPD) is a type of LCA output document that is governed by an ISO standard to enable consumers to compare the environmental and human health impacts of similar products, most commonly industrial products. It is important for agricultural scientists to be involved in the application of this standard when it involves agricultural production.

Research Focus

ARS scientists will:

1) provide leadership in defining the scope and methods for conducting scientifically rigorous agricultural LCAs, and
2) contribute to public databases for use by stakeholders in the LCA community.

Anticipated Products

- Standardized, scientifically rigorous methods for conducting agricultural LCAs
- Authoritative data sets for use in agricultural LCAs
- Recommendations for developing robust EPDs for agricultural products

Potential Benefits

- Stakeholders who are interested in conducting LCAs will have access to rigorous, publicly available data.
- Policy makers will have accurate data for assessing life cycle environmental footprints of agricultural processes and products.
- Consumers of agricultural products will have more readily available and understandable information to inform their consumption choices.

Problem Statement 4C: Enable assessment of agriculture and natural resource sustainability programs

Other government agencies have agriculture and natural resource sustainability programs created by policy makers to improve the overall sustainability of the U.S. agriculture sector. One role of ARS is to provide the science that other agencies can use to assess or improve the performance of their own programs. Policy makers can use these holistic assessments of program impact to improve programs.

Research Focus

ARS scientists will:

1) collaborate with other government agencies to improve their ability to collect relevant data for evaluating sustainability programs, and

2) work with stakeholders to co-produce knowledge products that enable the stakeholders to meet their sustainability goals.

Anticipated Products

- Recommended methods, models, and tools for Natural Resource Conservation Service (NRCS) to evaluate effectiveness of their conservation programs, for example, quantified conservation benefits of year-round soil cover in any cropping system, including both unharvested cover crops and harvested winter crops such as forage or biofuel feedstocks
- Recommended methods, models, and tools for Bureau of Land Management (BLM) to evaluate and improve the effectiveness of their management strategies for Western rangelands
- Improved models for state government agencies to use in their safety and sustainability programs, for example, the New Mexico Department of Transportation's highway safety programs related to blowing dust

Potential Benefits

- Policy makers have information to support conservation program decisions that enable greater adoption of conservation practices.
- Government agencies have increasingly accurate data as they produce regular natural resource status reports (for example, NRCS' Natural Resource Inventory Range and Pasture reports).
- Increased positive impact of government sustainability programs (greater effectiveness per dollar spent).

Component 4 Resources

Ames, Iowa
Beltsville, Maryland
Columbia, Missouri
Corvallis, Oregon
Las Cruces, New Mexico
Lincoln, Nebraska
Pendleton, Oregon
Raleigh, North Carolina
Temple, Texas
Tifton, Georgia
West Lafayette, Indiana