

The Agricultural Research Service
Agricultural System Competitiveness and
Sustainability National Program
Action Plan 2013-2017

NATIONAL PROGRAM 216 ACTION PLAN
AGRICULTURAL SYSTEM COMPETITIVENESS AND SUSTAINABILITY
UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE

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*Men and Nature must work hand in hand.
The throwing out of balance of the resources of nature
throws out of balance also the lives of men.*

Franklin D. Roosevelt

Vision

Help producers develop integrated solutions that solve their problems related to productivity, profitability, and natural resource stewardship.

Mission

This interdisciplinary research integrates information and technologies to develop new practices and dynamic systems that optimally enhance productivity, profitability, energy efficiency, and natural resource stewardship for different kinds and sizes of American farms. New configurations of practices are identified that utilize on-farm resources and natural ecosystem processes to reduce the need for purchased inputs and reduce production costs and risks. Precision management, automation, and decision support technologies are used to increase production efficiencies and enhance environmental benefits. Strategies are developed for sustainable production of bio-based energy products from farms. Production systems incorporate consumer preference and supply chain economic information to expand market opportunities for agricultural and other value-added bio-based products. Diverse improved agricultural systems will support the long-term financial viability, competitiveness, and sustainability of farms and rural communities, and increase food and fiber security for the USA and the world.

Background

Increasing demands are being placed on agriculture. Society expects a safe affordable supply of high quality nutritious food, a clean healthy environment, a growing economy that provides a comfortable standard of living for its citizens, and increased use of renewable sources of energy. These expectations are to be met using an area of land that has not changed appreciably over the last 100 years and a workforce that has decreased from nearly 50% to less than 5% of the population over that same time period.

Agricultural production has become much more productive and efficient. These improvements have been accomplished through increased use of conservation tillage practices; expanded use of irrigation; increased use of fertilizer and improvements in nutrient management; development and deployment of pesticides to reduce losses associated with weeds, disease, and other pests;

genetic improvements (including genetically modified organisms, GMO's) for crop management, improved traits, and increased yields; improvements in equipment; advances in crop processing and storage; and an infrastructure that facilitates timely distribution and export of agricultural products. Similar advances will be needed in the future to meet societal demands.

Modern agriculture must confront a number of major challenges in the near future. The population of the United States and the world is growing rapidly and agricultural productivity will have to increase to meet future food and fiber needs. The percentage of the population that is involved in agricultural production is small and declining with a majority of people living in urban areas. These demographics have resulted in a large segment of the population being unfamiliar with what agriculture provides and how it is provided. Housing needs and the infrastructure needed to support a growing population and migration of people from rural to urban areas has resulted in urban encroachment into productive agricultural areas and increased conflict between urban and rural life styles (e.g. odor and dust issues, increased traffic, and land use changes). In addition to space there is increasing competition for other resources essential to agriculture. In many regions of the country water supplies will likely not meet future demand. Agriculture is a major consumer of energy and expectations for increases in feedstock production for biofuels to reduce dependence on foreign energy are increasing. Finally, production agriculture will be required reduce emissions of greenhouse gases and sequester carbon to contribute to mitigating climate change and develop or shift practices to adapt to climate change.

Goal

The goal of the Agricultural System Competitiveness and Sustainability National Program (216) is to use interdisciplinary research to integrate information and technologies to develop new practices and systems that optimize productivity, profitability, energy efficiency, and natural resource stewardship for different kinds and sizes of American farms. Customers and Stakeholders for this research include farmers, consultants, biofuel industry, state agencies, NRCS, FSA, FAS, EPA, and other action agencies and organizations.

National Program 216 is part of Goal 6, Protect and Enhance the Nation's Natural Resource Base and Environment, of the ARS FY 2006-2011 Strategic Plan (<http://www.ars.usda.gov/SP2UserFiles/Place/00000000/ARSStrategicPlan2006-2011.pdf>). It also contributes to Goal 1 (Enhance International Competitiveness of American Agriculture) and Goal 4 (Enhance Protection and Safety of the Nation's Agriculture and Food Supply) of these strategic plans.

Approach

The National Research Council recently published a report titled *Toward Sustainable Agricultural Systems in the 21st Century*. In that report they identified four goals that define sustainable agriculture:

- Satisfy human, food, feed and fiber needs, and contribute to biofuel needs
- Sustain the economic viability of agriculture
- Enhance environmental quality and the resource base
- Enhance the quality of life for farmers, farm workers, and society as a whole

The approach used in this National Program is to conduct research that provides farmers with management practices, decision aides, and information needed to “move farming systems along a trajectory toward greater sustainability on each of the four goals”. Specific research topics will include: production systems for commodity and specialty crops, integrated crop – livestock systems, organic production systems, micro- and macroeconomic implications for these systems, and production system effects on air, water, and soil quality. Projects in this National Program will contribute to a database and participate in regional and national efforts to synthesize results using assessment tools and process based models. The overall goal is to make production agriculture more sustainable.

This National Program is organized into four problem areas:

- Food, feed, fiber, and feedstock production systems
- Production system economics
- Production system effects on natural resources
- Integration of production systems

These problem areas were developed based on customer input at regional planning workshops. These workshops provided customers, stakeholders, and partners with an opportunity to identify problems and research needs.

Progress in solving these problems will require cooperation among locations in this National Program, other ARS research programs, universities, and other agencies. Progress in achieving the objectives in this National Program will be communicated to clientele by partnering with university extension, NRCS, industry and other Technology Transfer mechanisms.

Planning Process and Plan Development

Planning for this National Program began in late 2011 when questionnaires were sent to customers and stakeholders requesting input to formulate problem areas relevant for the next five years. Responses were used to facilitate discussion at five regional customer workshops held on February 22, 2012, in Beltsville, Maryland; Auburn, Alabama; Ames, Iowa; Miles City, Montana; and Spokane, Washington. Introductory comments and reporting of discussions at the regional sites were shared among locations via teleconference at the beginning and conclusion of the workshop. Results from the workshop were used to develop this Action Plan.

ARS scientists identified research outcomes and products and the resources available to conduct the research for each problem area in this Action Plan. ARS scientists participating in NP216 will reference this Action Plan to develop project plans that describe the research they will conduct. These project plans contain detailed objectives, anticipated products and information generated, approach to be used, scientists and cooperators participating in the research, and a timeline and milestones to measure progress of the research. An independent panel of experts in this field will review all project plans and review comments will be used by ARS scientists to revise and improve their project plans prior to implementation.

Other relevant National Programs include Water Availability and Watershed Management (211); Climate Change, Soils, and Emissions (212); Agricultural and Industrial Byproducts (214); Food Animal Production (101); Food Safety (108); and Crop Production (305).

RESEARCH COMPONENTS

COMPONENT 1. ENHANCING THE YIELD FOOD, FEED, FIBER, AND FEEDSTOCK PRODUCTION SYSTEMS

The Action Plan Component *Enhancing the Yield Food, Feed, Fiber, and Feedstock Production Systems* addresses research problems in agricultural systems producing food (e.g. wheat, rice, peanut, vegetables, fruit), feed (e.g. soybean, corn, alfalfa), fiber (e.g. cotton), and feedstock (e.g. crop residue, oilseed, perennial biofuel crops). The primary function of research in this component is on understanding the underlying agroecological principles for development of technologies and production strategies for producing the food, feed, fiber, and feedstock needed by society.

Problem 1A: Crop Production Systems

Crop production in most regions is dominated by one or at most a few crops with additional minor crops grown to meet market demands. Cropping systems within a region must be adapted to the prevailing climate and soils. Knowledge and technology for improved and diversified agronomic crop production systems to increase yield, reduce input costs, break weed and disease cycles, reduce risk, and distribute labor over the cropping cycle are needed.

Research Needs

Evaluate diversified cropping systems that utilize cover crops, legumes and/or existing crop residues together with equipment modifications, conservation tillage practices and advanced technologies (site-specific management, automation, remote sensing, etc.) to improve soil quality, conserve natural resources and increase production efficiency, while reducing costs.

Field studies to evaluate the efficacy and economics of alternative pest control practices including precision farming technologies, beneficial cropping sequences, integration of low use chemical rates and high residue crops, and cover cropping to break pest cycles that include herbicide resistant weeds and reduce chemical use for different cropping systems.

Research cropping systems and production practices that efficiently utilize precipitation and irrigation water across dry and humid climate zones for multiple crops that include traditional row crops, vegetables, and biofuel crops.

Evaluate cropping systems and management practices that include using crop residues as feedstock for commercial and on-farm energy production.

Anticipated Products

- Develop guidelines for cropping systems that include cover crops and conservation tillage across irrigated and dryland moisture regimes to reduce yield risks, enhance soil structure, soil organic matter, microbial activity, and nutrient cycling.
- Produce equipment modifications that enhance equipment performance across different levels of residue to maintain surface coverage.
- Develop management tools and recommendations for integrated pest control that improves production across regional cropping systems.
- Provide alternative weed control practices that reduce dependence on herbicides and reduce input costs.

- Develop cropping systems with improved water productivity that increase crop yield and N-use efficiency, reduce input costs and conserve water resources.
- Produce guidelines for enhancing plant water availability using crop selection, crop rotation, planting geometry, etc.
- Improve management practices and develop equipment that utilize crop residue to preserve seed zone moisture across climate zones and in various cropping and tillage systems.
- Develop management practices that optimize water productivity in cropping systems that include vegetable, biofuel, specialty and other alternative crops.
- Develop management practices that improve nutrient use efficiencies for residue production as a feedstock for sustainable on-farm and commercial energy production.
- Determine effects of crop residue harvest on soil quality, soil fertility and long-term economic and agronomic sustainability

Potential Benefits

- Enable growers to make a successful transition into cover crops and conservation tillage, while reducing risk.
- Provide information on alternative crops and crop rotations that break weed and pest cycles and enhance soil quality leading to economically and environmentally sustainable production.
- Identify crop sequences, tillage systems and cover crop practices that promote beneficial nutrient cycling, maximize nutrient-use efficiencies and minimize loss of nutrients to the environment.
- Promote long term sustainable agricultural production through diverse cropping systems, increased cover crop use and reduced tillage.
- Identify best management practices for pest and weed control across various crops in regional cropping systems.
- Promote management tools for pest control in cropping systems that reduce yield losses associated with pests, prevent future herbicide resistant weed development in cropping systems while reducing herbicide use thereby enhancing profitability for producers, reducing negative environmental impacts and improving food safety.
- Improve understanding of interactions between crop rotation, residue management, tillage and irrigation as they affect the efficient utilization of water resources.
- Improve understanding of crop residue and/or cover crop residue effects on soil moisture preservation.
- Promote water management practices in both irrigated and non-irrigated cropping systems that enhance crop productivity and quality while protecting natural resources and maximizing water productivity.
- Improve nutrient use efficiency for residue production and develop farm scale technology for energy production.
- Produce bioenergy products for on-farm and commercial use in a sustainable system that maintains soil and water quality and improves farm profitability

Component 1A: Resources

ARS locations assigned to these projects include the following:

Ames, IA

Auburn, AL
Beltsville, MD
Corvallis, OR
Dawson, GA
Mississippi State, MS
Orono, ME
Pendleton, OR
Prosser, WA
Pullman, WA
Sidney, MT
Stoneville, MS

Problem 1B: Integrated Crop-Livestock Systems

Incorporation of livestock and poultry into crop production systems utilizes forage and grain to produce high protein products (e.g. meat, eggs, dairy). These systems often include utilization of land not suitable for cultivation for grazing or forage production. Animal byproducts in these systems are utilized as a fertilizer source resulting in tight coupling of nutrient cycles over relatively small scales. Knowledge and technology for improved integrated crop – livestock production systems are needed.

Research Needs

Development of management strategies that will effectively and sustainably integrate cropping and livestock production systems.

Anticipated Products

- Comparison of selected ecosystem services (soil quality, productivity, nutrient cycling and water use efficiency) and specific economic attributes in an integrated crop-livestock system versus a single enterprise conventional system.
- Web-based decision support tools aiding the selection of species mixtures for cover crops in specific environments and for specific functional purposes.

Potential Benefits

- Simpler and less expensive cover crop mixtures designed for specific functions and adapted to specific site-types.
- Develop practical recommendations to improve the economic, production and environmental aspects of integrated crop-livestock systems.
- Development of integrated crop-livestock systems that enhances multiple ecosystem functions including production, soil quality, nutrient cycling, and water use efficiency while decreasing off-farm inputs.

Component 1B: Resource

ARS location assigned to this project includes the following:

Mandan, ND

Problem 1C: Organic Production Systems

Certified organic production represents a growing component within agriculture. Knowledge and technology for providing nutrients, controlling weeds and other pests, and increasing yields are needed for improved organic production systems.

Research Needs

Field research to improve understanding of biological and cultural management practices including yield limiting factors, nutrient and weed management, and integrating cover crop management techniques into organic production systems (grain and vegetable) to control pests and improve organic crop yields.

Field studies to implement organic cropping systems into integrated cropping-livestock farming operations that include improving organic forage yield and quality with organic inputs, while improving nutrient retention.

Anticipated Products

- Recommendations for organic systems that include guidelines for using cover crops including optimum mixtures with nutrient sources like poultry litter or compost to optimize crop yields, weed control, P and N management, and incidence of pathogens and pests.
- Recommendations for the use of organic inputs to reduce risk of nutrient loss in organic production systems that include forages and integrated crop-livestock operations.

Potential Benefits

- Identify best management practices for better disease, pest and weed control, improved N use efficiency, reduced P loading to streams, while improving soil quality in organic production systems.
- Enhance the longevity and sustainability of organic production by demonstrating the viability of these systems to increase numbers of organic producers and improving production efficiency of existing producers.
- Increased use of organic inputs, while reducing risk of nutrient loss from organic production systems.
- Increase adoption of organic management practices designed to retain nutrients.
- Increase supply of organic forages.

Component 1C: Resources

ARS locations assigned to these projects include the following:

Ames, IA
Auburn, AL
Beltsville, MD
Morris, MN
Orono, ME
Salinas, CA

COMPONENT 2: ENHANCING PRODUCTION SYSTEM ECONOMICS VIABILITY

The Action Plan Component *Enhancing Production System Economics Viability* addresses research problems on the profitability of agricultural production systems. The primary function of research in this component is on understanding the economic factors affecting production system profitability and developing strategies for profitable food, feed, fiber, and feedstock production.

Problem 2A: Farm-Scale Economics

Volatile commodity prices and increasing input costs represent economic challenges for producers. Understanding the factors effecting farm-scale profitability and developing strategies for optimizing producer income are needed.

Research Needs

Assess farm and field-scale economic risks, returns, and factors affecting likelihood of adoption for dryland agricultural systems, including crop sequence, cover crop, integrated crop-livestock, and biofuel feedstock production systems.

Research plots and production fields will be used to determine factors contributing to economic return and profitability of small-scale and vegetable production systems; alternative crops will be explored for their potential to improve profitability of small-scale production systems and balance returns from food, fuel or fiber.

Anticipated Products

- Identification of systems that increase economic returns and provision of ecosystem services.
- Interactive map-based decision tool identifying biofuel feedstock prices needed for profitable production, farmer adoption, and impacts of production on economic returns and provision of ecosystem services.
- Economically feasible cropping systems for small-scale producers and local production systems.

Potential Benefits

- Information is used by producers in adopting practices that increase economic returns and provision of ecosystem services.
- Information is used in targeting development of biofuel industry to areas that maximize economic viability and provision of ecosystem services.
- Development of sustainable biofuel production industry.
- Identification of key points of flexibility allowing adaptation to greater economic return.
- Production systems for conventional and small-scale farming operations that improve profitability.

Component 2A: Resources

ARS locations assigned to these projects include the following:

Mandan, ND

Orono, ME

Stoneville, MS

Problem 2B: Macro Economics

Agricultural production represents a significant component of the United States economy and makes a positive contribution to the country's balance of trade. Strategies for optimizing the contribution of agricultural production to the United States economy are needed.

Research Needs

Develop field-level cost and production data associated with biofuel feedstock production alternatives for use in national scale economic assessments of biofuel development impacts.

Anticipated Products

- National assessment of economic and natural resource impacts of biofuel industry alternatives.

Potential Benefits

- Information is used in identifying most promising biofuel industry alternatives for economic and sustainability goals.
- Development of sustainable biofuel production industry that contributes to national energy security.

Component 2B: Resources

ARS location assigned to this project includes the following:

Mandan, ND

COMPONENT 3: PRODUCTION SYSTEM EFFECTS ON NATURAL RESOURCES

The Action Plan Component *Production System Effects on Natural Resources* addresses research problems on the soil, water, and air resources associated with production systems. The primary function of research in this component is to understand the physical, chemical, and biological processes in production systems and develop strategies for meeting air, water, and soil quality expectations of society.

Problem 3A: Air Quality

Agricultural production systems interact with the atmosphere affecting air quality. Management practices that maintain or improve air quality are needed.

Research Needs

Field and plot studies measuring dust and PM10 emissions from diversified cropping systems.

Monitoring and quantify soil-atmosphere greenhouse gas emissions and N and C cycling on various irrigated and dryland cropping, and integrated crop-livestock production systems designed to reduce soil loss, and increase nitrogen use efficiency, soil quality, weed control and other agronomic factors.

Anticipated Products

- Accurate estimates of soil loss and PM10 emissions from diversified cropping systems of arid regions.
- Increased scientific knowledge of how crop and harvesting choices influence the amount of post-harvest crop residue and the susceptibility of soil to erosion by wind.
- Development of diversified cropping systems with conservation tillage and reduced rates of N fertilization that increase soil C sequestration, improve N cycling and N use efficiency, enhance soil quality and productivity, reduce greenhouse gas emissions, increase N-use efficiency, and sustain crop yields.
- Better understanding of interactions among cover crop management, manure, and tillage on greenhouse gas emissions.
- In depth understanding of the impact of various management practices on soil microbial communities and environmental factors that regulate production of N₂O in soils.

Potential Benefits

- Soil conservation recommendations from the development of harvesting strategies for high residue cereals.
- Mitigation of wind erosion and improved air quality in arid regions.
- Cultural and biological approaches to improve soil and residue carbon and nitrogen cycling and reduce greenhouse gas emissions.
- Improve model estimates of the global warming potential of cropping systems.
- Recommendations for reduced greenhouse gas emissions from diverse cropping systems.
- Recommended practices for use in diverse crop and integrated crop and livestock management practices that will reduce soil greenhouse gas emissions, increase soil organic C, improve N use efficiency, and other soil quality parameters.

Component 3A: Resources

ARS locations assigned to these projects include the following:

Beltsville, MD
Mandan ND
Pendleton, OR
Pullman, WA
Sidney, MT

Problem 3B: Water Quality

Agricultural production systems affect surface and ground water resources. In many regions production is dependent on irrigation. Management practices that maintain water quality and optimize water use efficiency are needed.

Research Needs

Monitor short- and long-term soil and drainage tile N-leaching/loss potential and water flux under irrigated, dryland, and cover/rotation crop, and soil management systems.

Field research quantifying contributions of grass cover crops in scavenging residual N following corn.

Calibrate SWAT using existing data sets from the intermediate precipitation zone in the Columbia Plateau and determine potential changes in crop productivity, hydrology, and sediment and nitrogen loads resulting from a shift away from winter wheat/fallow rotation to the cropping systems investigated in Products 1A.1 and 1A.2.

Research plots and production fields will be used to determine crop water use in humid areas for alluvial soil types and for a range of management practices (row spacing, planting date, cultivars).

Web-based water management tools will be developed, implemented in C++ and Java, and delivered through state extension.

Determine crop and cropping systems WUE_i and $RWUE_i$ for a variety of irrigation methods

Determine the impact of biochar application, irrigation method, and cropping system on WUE_i and $RWUE_i$

Anticipated Products

- Quantification of N-leaching under irrigated and dryland cropping systems and cultural practices by field measurements and models.
- Improved knowledge of cover crop water use and nitrate scavenging.
- Database containing tile drain water flux and water quality data from organic cropping systems.
- Nitrogen and water balance estimates for cropping systems.
- Quantification of the above- and belowground contributions of cereal rye and wheat to N scavenging.
- Costs for cropping system implementation per ton of sediment and kg of N reduction.
- Stream flow and sedimentation prediction within the low and intermediate precipitation zones of the Columbia Plateau.
- Establish change in stream sediment loads resulting from conservation buffers.
- Web-based Irrigation scheduler and water management tools as well as WUE_i and $RWUE_i$ values for different irrigation options.
- Determination of whether biochar application at varying rates impacts WUE_i and $RWUE_i$ as well as yield, and economic returns.

Potential Benefits

- Improved N use efficiency and productivity in reduced tillage irrigated cropping systems.
- Demonstration that cover crops can reduce nitrate leaching losses to tile drainage in both tilled and no-till systems.
- Recommendations to maintain or improve water quality in organic cropping systems with less nitrogen losses to surface and ground water.
- New guidelines for increased crop water productivity and reductions in N leaching by better selection and management of cropping systems and improved farm decision-making tools.

- Improved ground water quality, and reduced pollution of fragile marine ecosystems.
- Acceptance that cover crops are a viable nitrate mitigation strategy that also provides erosion protection and soil quality improvement.
- Increased adoption of organic management practices that improve water quality.
- Improved understanding of cover crop and commodity cover crop root contributions to N scavenging; quantification of commodity cover crops to N scavenging.
- Improve landscape models that are used to assess the role cover crops play in N scavenging; increase use of commodity cover crops.
- Increased understanding of environmental advantages/disadvantages resulting from diversification of cropping systems in terms of water quality and soil conservation.
- The sustainability of agricultural production systems and off-farm environmental quality is increased through more water and N use efficient cropping systems and establishment of conservation buffers contributing to ecosystem services.
- Crop coefficients and water use for conventional and alternative crops in humid areas.
- Producers will have agronomic and economic data on the most efficient method of irrigation.
- Water management tools and web-based irrigation scheduler will improve timing and amount of water applications, improve crop yield and quality, and reduce excess water use in crop production.
- Knowledge on the impacts (water, economic, environmental) of applying biochar in Lower Southeast cropping systems.

Component 3B: Resources

ARS locations assigned to these projects include the following:

Ames, IA
 Beltsville, MD
 Dawson, GA
 Pendleton, OR
 Portageville, MO
 Salinas, CA
 Sidney, MT
 Stoneville, MS
 Stuttgart, AR

Problem 3C: Soil Quality

Agricultural production systems affect soil physical, chemical, and biological properties. Management practices that maintain or improve soil quality are needed.

Research Needs

Field and laboratory studies to identify residue management, crop rotations, and farming practices that maximize the contribution of soil microbial communities to enhance soil sustainability and to better understand factors controlling soil biological community structure and function and their relationship to soil quality and production performance through a cropping sequence.

Monitor short- and long-term changes in biotic and abiotic soil quality factors as a function of tillage, rotation, and cover crop management, which may also include crop-livestock systems.

Develop relationships between individual/integrative indicators of soil quality and water balance/environment/productivity in organic and non-organic production systems.

Field research in long-term agricultural research (LTAR) projects on mechanism of C sequestration in diverse conventional and organic cropping systems.

Characterize and quantify the effects of soil management practices and amendments, including char derived from biofeedstock gasification, to enhance soil quality and carbon and nitrogen dynamics for improving productivity of crop and soil.

Anticipated Products

- Production practices that create field environments that favor the development of microbial populations that reduce input cost and improve crop productivity.
- Increased scientific knowledge of the microbial response (diversity, abundance, activity) to residue management and diversified cropping systems.
- Diversified cropping systems that provide benefit through reducing pathogen pressure (i.e., break crop effects or bio-fumigation) and contribute to plant available N (legumes).
- Improved knowledge of the dynamics of microbial community structure and function and subsequent impact on indicators of soil quality and functional resilience in diverse cropping systems.
- Development of management practices for irrigated and dryland cropping systems that enhance soil structure, soil organic matter content, soil microbial activity, N-cycling to improve farm sustainability.
- Improved knowledge of the short and long-term effects of soil quality.
- Improved soil quality parameters as influenced by tillage, harvest method and crop diversification under a range of soil conditions and climates.
- Relate improvements in infiltration, aggregate stability, and plant available to yield stability under drought conditions.
- Improved understanding of relationships among individual / integrative indicators of soil quality and water balance / environmental / productivity in organic production systems.
- Better understanding of physical, chemical and biological factors impacting soil C sequestration in soils.
- Development of management practices that improve key soil functions through enhancement of soil physical, chemical, and biological properties.
- Production practices will be identified that improve soil-enhancing factors that maximize crop productivity and soil quality.

Potential Benefits

- New knowledge of microbial communities that impact weed cycles.
- Identification of belowground benefits/detriments from diversified cropping systems and residue management practices.
- Management strategies for improving soil biological function.

- Information on management practices that can promote abundance and effect of microbial soil quality indicators.
- Approaches to utilize microbial communities, or their products, to reduce crop input costs.
- Use of microbial N contribution estimates during fallow to refine rates of N application.
- Information on the effects of management practices on soil quality, productivity, and relationship between soil quality, crop yields, and environmental quality will lead to improved sustainable cropping system practices.
- Technology transfer programs on farm management practices that enhance soil structure, soil organic matter content, soil microbial activity, N-cycling that improve farm sustainability.
- Improve crop yields by increasing surface soil organic matter contents.
- Soil management strategies that are less reliant on tillage, improve quality, and plant available water.
- Soil carbon gain upon conversion to heavy residue crops and minimum tillage due to increase in light carbon fraction.
- Recommendations to maintain and improve soil and water quality in organic cropping systems.
- Recommendations for increasing C sequestration in diverse cropping systems.
- New and/or improved management practices that enhance soil biophysical attributes and nutrient cycling efficiency.
- Improved long-term soil quality and carbon sequestration on organic and conventional farms.
- The sustainability of agricultural production systems is increased through increased soil C accretion, which promotes aggregate stability and water infiltration.
- Increased adoption of cover crops through a better understanding of their benefit as a valuable soil quality enhancer.
- Increased adoption of organic management practices that improve soil and water quality.
- New and/or improved management practices that enhance soil hydrological function and increase agroecosystem resilience.
- Identified soil factors will serve as ecosystem service indicators of soil health, carbon cycling, and trajectory of improved cropland sustainability.
- New knowledge of soil carbon dynamics and soil quality will improve the calibration of soil carbon, SWAT, and related decision aid models.
- On-farm use of the gasification byproduct char as a soil amendment will serve as a value-added product, enhance resource conservation, and improve soil quality and farm sustainability.
- Knowledge of cropping system implementation to subsequent changes in soil carbon dynamics will improve farm field/watershed management decisions and enhance farm sustainability.

Component 3C: Resources

ARS locations assigned to these projects include the following:

Ames, IA
 Auburn, AL
 Beltsville, MD
 Corvallis, OR
 Mandan, ND

Orono, ME
Pendleton, OR
Pullman, WA
Salinas, CA
Sidney, MT

Problem 3D: Environmental Quality

Altering management practices to reduce negative effects on one component of the environment often have the unintended effect of shifting the impact to another part of the environment.

Synthesis of land management and effects on natural resources is needed to insure that agricultural production practices maintain or improve environmental quality.

Research Needs

Quantify multiple environmental impacts of on-farm energy production, changing stand duration, tillage, and nitrogen use patterns in management of seed and cereal crops in western Oregon through supercomputer modeling.

SWAT and other models will be used to explore erosion, run-off, and water use in row crop production systems within watersheds and sub-watersheds for various management practices.

Conduct life cycle assessments of different dryland crop production systems to consider resource and energy efficiency, water consumption, GHG emissions, and waste production.

Generation of data to investigate the interactions of the ecology and natural resources of the area with temporal and spatial variable-rate inputs into cotton production.

Development of carbon and nutrient (N, P, K) budgets for long-term agricultural research (LTAR) projects.

Integrated assessments (including life cycle analysis) of multiple environmental impacts of conventional and organic grain farming.

Anticipated Products

- Pareto front calculation of trade-offs among soil and water quality, farm profitability, and ecosystem services in western Oregon.
- Alternate tillage and cropping practices to improve water management in agricultural areas.
- Inventories of energy consumption, water consumption, and CO₂ emissions that occur from wheat-based production systems in dryland areas of the Columbia Plateau.
- Assessment of the contribution of individual emissions to the environment and identification of the process from which they arise.
- Geo-referenced spatial and temporal data sets of inputs and yields that can be used to better manage cotton production.
- Knowledge of long-term impacts of organic and conventional farming practices on carbon and nutrient budgets.

- Knowledge of long-term impacts of organic and conventional farming practices on multiple environmental impacts.

Potential Benefits

- Description of likely changes in water quality and wildlife habitat suitability as the mixture of crops grown changes in response to potential restrictions on pesticides, fertilizer, and plant genetics.
- Database of optimal trade-offs for stakeholders needing to compare and simultaneously evaluate conflicting goals regarding “green taxes,” pesticide restrictions, and price/availability of desired agricultural commodities.
- Identification of water flows within agricultural areas based on production practices.
- Improved water management in the Mississippi Delta.
- Accounting of each component in the system with regard to environmental impact.
- Growers make informed decisions on best crop management practices that minimize environmental impact.
- Ecological and natural resource based management systems.
- Guidance for tightening nutrient budgets thereby reducing off-farm impacts on air and water quality.
- Improved environmental performance of diverse cropping systems.
- Recommendations on most sustainable farming practices.
- Incorporation of information into policies that promote sustainable agriculture.

Component 3D: Resources

ARS locations assigned to these projects include the following:

Beltsville, MD
 Corvallis, OR
 Pendleton, OR
 Pullman, WA
 Stoneville, MS

COMPONENT 4: INTEGRATION OF SUSTAINABILITY GOALS

The Action Plan Component *Integration of Sustainability Goals* addresses research problems that must be overcome to synthesize the data so that sustainability at the farm/regional/or larger scales can be assessed. This synthesis is necessary to insure that progress is being made in all sustainability goals as we work to move farming systems along a trajectory toward greater sustainability. The primary function of research in this component is to develop a database, develop analytical tools for processing datasets, and use or develop statistical methods, assessment tools, and models to synthesize results and compare systems at various scales.

Problem 4A: Database Development

Agricultural production research is conducted at a large number of locations. Comparison of results is hampered by lack of access to data. Development of a database for storage and access is needed to integrate and validate research across locations, regions, and nationally.

Research Needs

Identify types of data to be produced and their associated metadata needs. Identify likely output formats and intermediate processing needs. Establish long-term capabilities to populate and maintain the system.

Utilizing research plots and production fields, collect information on plant growth, soil nutrients, hydrology, weather, cultural practices, dates of operation, and yield for a variety of management practices.

Develop a web-based database management system for hosting data from NP216 projects nationwide.

Anticipated Products

- Development of a common format for detailed data bases on all aspects of crop production under various cropping systems and management practices.
- Online database management system optimized for searching, browsing, and extracting well documented, high quality research data sets relevant to cropping systems management.
- Data portal for accessing and examining data from different ARS locations.

Potential Benefits

- Methods for relational database development and evaluation for long-term experiments.
- A database of soil quality and yield potentials of specialty and biofuel crops.
- Research analysis across spatial and temporal scales on impacts of alternative management systems on crop production and environmental quality.
- Information is available to research workers to address production practices that improve crop and soil quality, and reduce weed and pest problems, in the contexts of profitability and resource sustainability.
- Single point of entry to data sources, which serve the needs of ARS locations and their cooperators, and the public.
- Data are utilized from many different databases, which reduce redundancy in data storage and allows for flexible data integration.
- Data sharing allows meta-analysis of agricultural practices and systems to better evaluate sustainability.
- Data from various locations can be used to synthesize knowledge and advance science.

Component 4A: Resources

ARS locations assigned to these projects include the following:

Ames, IA
Auburn, AL
Beltsville, MD
Corvallis, OR
Dawson, GA
Fort Collins, CO
Mandan, ND
Mississippi State, MS
Morris, MN
Orono, ME

Pendleton, OR
Prosser, WA
Pullman, WA
Salinas, CA
Stoneville, MS
Sidney, MT

Problem 4B: Synthesis and Modeling

Modern data collection methods are capable of generating very large datasets that are difficult to process and extract meaningful information. Methods for processing, filtering, and incorporating these datasets into a common format and statistical methods, assessment tools, and agronomic models to synthesize and compare results across locations is needed to better understand underlying processes and responses to modern production practices.

Research Needs

Linkage of data from databases developed under 4A with existing simulation models.

Use available simulation software to evaluate crop growth and development, response, and productivity as influenced by climate change, field conditions, and management practices.

Use available simulation software to evaluate ecosystem services and environmental impact as influenced by cropping systems, soil factors, and management practices.

Quantify Genetic x Environment x Management (G x E x M) interactions in biophysical parameters of agricultural systems models; improve models and parameterization for spatial applications over a region.

Anticipated Products

- Validation of existing crop models for each region and cropping system.
- Analysis of the impact of alternative management practices and climate conditions on the response of agricultural production systems.
- Simulation and statistical models validated for complex crop rotations and ecosystem-services at a watershed level in response to multiple factors and their interactions.
- Simulation and statistical models validated for complex crop rotations and environmental impact.
- Case studies of spatial predictions of crop production, water use, water quality impacts, and management adaptations to climate changes, which can be regionalized to an area of interest.

Potential Benefits

- Calibration and validation of existing crop and soil models for each cropping region.
- Model simulation outcomes will aid agribusiness, policy makers, investors, land managers, environmentalists, & the general public to make appropriate land use planning and management decisions.
- Quantification of the effect of crop choices and crop sequences on water conservation strategies.

- New decision making tools to aid growers in crop selection and management for optimal farm sustainability.
- Landscape scale evaluation of management practices.
- Guidelines to develop and manage sustainable production systems.
- New knowledge of the major driving variables and factors that influence regional variations in results.

Component 4B: Resources

ARS locations assigned to these projects include the following:

Ames, IA
Auburn, AL
Beltsville, MD
Corvallis, OR
Fort Collins, CO
Mandan, ND
Mississippi State, MS
Morris, MN
Pendleton, OR
Pullman, WA
Prosser, WA
Sidney, MT