**National Program 216- Agricultural System Competitiveness and Sustainability**
**National Program Annual Report for FY2016**

***Vision**: Integrated solutions solving problems of productivity, profitability, efficiency, and natural resource stewardship.*

## *Mission*

This interdisciplinary research program integrates information and technology to develop new practices and dynamic systems that optimally enhance productivity, profitability, energy efficiency, and natural resource stewardship for 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 U.S. and the world.

## *Introduction*

Fiscal year 2016 research supported the 2013-2017 Action Plan for National Program (NP) 216. The Action Plan and the projects were developed from comprehensive stakeholder input gleaned from national stakeholder workshops. These efforts are documented online at: http://www.ars.usda.gov/research/programs/programs.htm?NP_CODE=216 and include workshop documents, strategic vision, the action plan, and accomplishment and external assessment reports.

The goal of NP216 is to conduct research that addresses the challenges described above, and specifically to provide farmers with management practices, decision aids, and information needed to move farming systems toward greater sustainability. The program has four components:

1. *Food, feed, fiber, and feedstock production systems.*
    - Research addresses 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), and is designed to understand the underlying agroecological principles for developing technologies and production strategies for generating food, feed, fiber, and feedstock.
2. *Production system economics*
    - Research addresses the profitability of agricultural production systems, and is designed to understand the economic factors affecting production system profitability and to develop strategies for profitable food, feed, fiber, and feedstock production.
3. *Production system effects on natural resource*

- Research addresses soil, water, and air resources associated with production systems, and is designed to understand the physical, chemical, and biological processes in production systems and develop strategies for meeting air, water, and soil quality expectations of society.

4. *Integration of sustainability goals*
    - Research addresses problems related to synthesizing data needed to assess sustainability at the farm/regional/or larger scales. This synthesis is necessary to insure that progress is being made in all sustainability goals. Research is designed to develop and use databases, analytical tools for processing datasets, statistical methods, assessment tools, and models to synthesize results and compare systems at various scales.

Late in the five-year research cycle an additional research component was added to the NP216 action plan:

5. *Closing the yield gap through interactions of Genetics x Environment x Management (G x E x M)*
    - Research addresses yield gap through the interactions of genetics with environment and management (G x E x M). The rationale for a departure from the classic G x E interaction is to highlight the effects of climate variability on the environment factor, and the opportunities for management to enhance performance of genetic resources under varying environmental conditions. Feedback from producers about GxExM is universally favorable, as this is how they "view the world".

This component seeks to foster more interdisciplinary research for systems-level solutions.

Specific research topics of NP216 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.

## ***News for NP216 During 2016***

Many of the NP216 projects include significant domestic and international collaborations including government, industry and academia. These collaborations provide opportunities to leverage funding and scientific expertise for USDA-ARS research and accelerates dissemination of ARS research results, thus enhancing the impact of ARS research programs.

During FY2016, 88 full-time scientists working at 23 research units across the U.S. actively engaged in 25 ARS-led and 85 collaborative research projects. The gross fiscal year 2016 appropriated funding for NP216 was $21 million.

## **Personnel News for NP216**

**New additions to the NP216 team during 2016 included:**

- The Range Management Research Unit, Las Cruces, NM, welcomed the following in 2016: **Mr. Leopoldo Rocc**a from INIA, Peru, whose expertise is in rangeland health assessment; **Dr. Jim Miller**, University of Illinois-Urbana, whose field of study is land use dynamics; **Dr. Glenda Wardle**, University of Sydney, whose field of study is dryland ecology and population dynamics; and postdoctoral research associate **Dr. Matt Petrie**, previously of the University of Wyoming. Dr. Petrie is studying ecohydrology, specifically vegetation dynamics linkages.
- The Northern Great Plains Research Laboratory, Mandan, ND welcomed the following postdoctoral research associates in 2016: **Dr. Derek Faust** received his PhD from Mississippi State University. He is working on integrated crop-livestock systems as part of a USDA-NIFA grant, with expertise in water quality. **Dr. Krishna Pokharel** received his PhD from Kansas State University. He is studying conversion of oilseed to jet fuel as part of a USDA-NIFA grant. His expertise is in agricultural economics. NGPRL also had a visiting graduate student in 2016; Sher Afzal is from University of Agriculture Faisalabad, Pakistan, and worked on integrated crop-livestock studies.
- **Dr. Oliva Pisani j**oined the Southeast Watershed Research Laboratory, Tifton, GA. Dr. Pisani is a chemist studying soil, water, and plant tissue nutrients and organic constituents.
- **Dr. Ann M. Klein,** a recent Ph.D. from University of Oregon, joined the Soil and Water Conservation Research Laboratory in Pendleton, OR. Dr. Klein studies the impact of oilseed rotations on the structure and function of microbial communities in the rhizosphere of wheat.

**The following scientists contributing to NP216 retired from ARS during FY2016:**

- **Dr. Frank Young** of the Northwest Sustainable Agroecosystem Research Unit, Pullman, WA, retired from ARS in January 2016 after 35 years of service with the agency.

The distinguished record of service of Dr. Young is recognized world-wide and he will be missed by NP216, ARS and the scientific community. Our best wishes go out to him.

**The following scientists in NP216 received prominent awards during FY2016:**

- **Dr. Liwang Ma** of the Rangeland Research Systems Research Unit, Cheyenne, WY, received the L.R. Ahuja Ag Systems Modeling Award from the Soil Science Society of America.
- **Dr. Jason Karl** of the Range Management Research Unit, Las Cruces, NM, was selected as ARS's 2016 Plains Area Early Career Scientist for his work bringing science-based principles and technologies to management of public rangelands.
- **Dr. Kris Havstad** was awarded a 2016 USDA Abraham Lincoln Honor Award, for creating a center of excellence in rural America by uniting science and outreach networks at the Range Management Research Unit in Las Cruces, NM.
- **Dr. Dinku M. Endale** of the Southeast Watershed Research Laboratory, Tifton, GA, was a recipient of the Southeast Regional 2016 Interagency Partnership Award by the Federal Laboratory Consortium for Technology Transfer (FLC) in recognition of the work regarding "By-product Gypsum to Reduce Runoff Pollution and Improve Water Quality."

Our congratulations and thanks go to these scientists for their outstanding work.

The quality and impact of NP216 research was evidenced during FY2016 by the following:

- Over 100 refereed journal articles published;
- 1 new patent issued and another applied for;
- Administration or development of 16 web sites for academia or stakeholders.

In 2016, NP 216 scientists participated in research collaborations with scientists in Australia, Belgium, Brazil, Canada, China, Colombia, Egypt, France, Germany, Honduras, India, Italy, Kenya, Korea, Mexico, Mongolia, Mozambique, Namibia, Pakistan, Spain, and United Kingdom.

## Plans for 2017

During 2017 a retrospective report will be produced that documents progress on the research needs described by the 2013-2017 action plan. A webinar open to stakeholders and customers will present this information and a review panel will assess how well the program met these needs.

A new five year action plan and research objectives for each project will then be created. Formulation of the action plan and project objectives will incorporate the perspectives of stakeholders and customers, USDA administrators, ARS collaborators and the scientific community.

## Selected Research Results for FY2016

This section presents significant and high impact research results that address specific components of the FY2013 – 2017 action plan for NP216.

### Component 1. Enhancing the Yield of Food, Feed, Fiber, and Feedstock Production Systems

**Long-term reduced till with continuous cropping reduces soil carbon and nitrogen losses.** The long-term consequences of reduced till coupled with crop rotation on the carbon and nitrogen status of cropping systems has yet to be assessed, thus raising questions concerning their sustainability. A 30-year experiment by ARS researchers in Sidney, Montana on the effects of low tillage and continuous crop rotation on soil carbon and nitrogen on land originally converted from grassland showed that no-till or reduced-till continuous cropping resulted in a 10-15% loss of pre-cropping soil organic carbon and total nitrogen, which is considerably lower than 30-35% losses resulting from a conventional-tillage, crop-fallow system. The conventional system, however, increased inorganic nitrogen levels over that of the no-till continuous cropping system. As soil organic carbon and total nitrogen are critical to soil quality and productivity, farmers can better manage soil quality by adopting no-till or reduced till with continuous cropping.

**No agronomic difference between GMO vs Non-GMO Corn**. The rapid and widespread use of genetically engineered crops in the U.S. can be attributed largely to the perceived economic advantage over conventional crops under pressure from insects and weeds. Little is known regarding the potential differences in agronomic characteristics and protein expression between genetically engineered plants and the impact on soil and crop productivity and our ecosystem. Research conducted by ARS scientists in Brookings, South Dakota, evaluated the agronomic characteristics of 18 different commonly used corn hybrids including three conventional hybrids (non-genetically modified) and their corresponding transgenic modifications. There was no glyphosate use and no significant insect pest pressure during these experiments. Results showed that without significant insect and weed infestation there was no difference in grain yield, or above ground corn biomass. The limited differences observed in plant nutrient concentration between hybrids in this experiment were not considered agronomically important, and are consistent with natural genetic variability among the genotypes tested, rather than the presence or absence of any particular trait. This study could serve as a baseline for comparison with future data from similar experiments conducted under various levels of insect or weed pressures, or following glyphosate applications, to more fully evaluate the costs and benefits of widespread GMO use.

**Improved cover crop management can reduce the risk of increased corn seedling root diseases.** Cereal rye cover crops in corn-soybean rotations have been shown to significantly reduce erosion, decrease losses of nitrogen (N) and phosphorous (P), and increase soil organic matter; however, corn yields following cereal rye cover crops have been reduced during some years. One possible reason is that cereal rye may be acting as a host for pathogens that are sometimes transferred to corn seedlings after rye termination. ARS scientists in Ames, Iowa, showed that this does occur for *Pythium* and *Fusarium*, fungal pathogens of corn, in field and controlled environment studies. Understanding the role of cover crops in disease incidence of the following corn crop will enable the development of management strategies to overcome this risk factor. The impact of this research will be that farmers, extension personnel, crop advisors, and Natural Resources Conservation Service (NRCS) conservationists will be able to use and manage cover crops more effectively, which will lead to the greater environmental benefits of cover crop adoption with less risk to corn yield.

**Alternate methods to manage pigweed in conservation tillage.** Weed control in conservation tillage is currently under threat due to herbicide resistant pigweed and other troublesome weeds. Inversion tillage, in which a layer of soil (often 6 -12") is flipped over, burying surface residues (and associated weed seeds, spores and insect larva and eggs), is being advocated by some in cooperative extension because it can be effective at reducing weed emergence. A multi-state field experiment was conducted by an ARS researcher in Auburn, Alabama in collaboration with researchers at Auburn University, Clemson University, University of Georgia, the University of Tennessee, Alabama NRCS, and Cotton Incorporated, evaluating weed control provided by integrating high-residue cover crops and herbicides following conservation tillage, including a strategic inversion tillage system, compared to a winter fallow conservation system. Results indicated that a one-time inversion tillage operation followed by a return to conservation tillage may aid in the reduction of weed density; however, this system will likely not provide adequate control when an extremely high population density of glyphosate resistant Amaranthus is present, highlighting the continued need for a highly efficacious herbicide system. Cropping systems that integrate cultural practices such as high-residue cover crops, crop rotation, and alternative herbicide systems can thus be utilized to improve herbicide resistant weed control. Results from this study will increase weed control while reducing reliance on tillage to manage hard-to-control weeds.

**Banding placement of pelletized broiler litter maintains cotton yield and economically benefits cotton growers**. Many row crop farmers in the southeastern U.S. using broiler litter to fertilize cotton disregard the residual nitrogen (N) supplied by the broiler litter application during the preceding year, and apply the full N needs of cotton from inorganic N sources the first year after broiler litter use ceases. This practice often leads to over-application of N, associated economic loss and potential environmental harm from excess N. ARS scientists at Mississippi State, Mississippi, evaluated the residual effects of precision band placement of pelletized broiler litter relative to recommended commercial N fertilizer applications and found that similar yield was sustained when the prior litter plots were fertilized with a reduced rate of inorganic fertilizer N, thus taking advantage of the litter residual N. This strategy reduces the use of inorganic N fertilizers and enables growers to maximize the return on their nutrient management practices.

**Legume cover crop performance is critical to determining poultry litter application rates.** Applying animal by-products to meet crop nitrogen (N) needs often results in soil phosphorus (P) buildup that poses environmental risks. Legume cover crops, such as hairy vetch, used in combination with animal by-products, can help balance N and P inputs, but information is lacking on appropriate by-product application rates with hairy vetch. ARS scientists in Beltsville, Maryland, found in a two-year study that when hairy vetch biomass production was good, neither organic amendments nor mineral fertilizers increased corn yield further- indicating that vetch alone could meet all of corn's nitrogen needs. During a year with poor vetch performance, vetch provided no benefit to corn, while organic amendments increased corn grain yield without raising concerns of soil P buildup at the applied rates. While benefits of four organic amendments tested were very similar, costs differed substantially. Economic returns from using poultry litter were substantially greater than for the other three materials (pelletized poultry litter, feather meal, and a pelletized poultry litter-feather meal blend). Results will be of interest to organic and conventional farmers deciding whether to use a hairy vetch cover crop, and to policy makers and other advocates seeking to balance production with environmental consequences of agriculture.

**Crop production varies considerably due to variability of meteorological patterns.** ARS scientists in Beltsville, Maryland, analyzed data from a long-term agroecological research project and found that annual fluctuations of corn and soybean yields varied on a periodic basis, with periods lasting about 4½ years. Precipitation and air temperature during critical periods in the early and late growing seasons explained much of the yield variability, with precipitation during the late vegetative and early reproductive phases of crop growth accounting for the majority of variability in yield for both crops under five different management systems. Meteorological conditions at the site were partially explained by El Niño Southern Oscillation sea surface temperature (SST) patterns, such that the lowest critical period precipitation and resulting yield anomalies always occurred during years with extreme La Niña and El Niño SST anomalies, and the highest critical period precipitation and resulting yield anomalies always occurred during years with neutral SST anomalies. The efficiency of grain yield per unit precipitation was higher in conventional than organic systems, highlighting the importance of crop management for optimizing production when responding to meteorological variability. Results will be of interest to farmers when making production decisions, and strategic decision makers concerned with policies affecting agricultural production.

## Component 2. Enhancing Production System Economics Viability

**System for segregating hard red wheat by protein content rewards growers.** By bulking harvested grain together, conventional harvesting practices ignore areas of valuable, high-protein wheat within fields that command higher prices. To remedy this situation, ARS scientists in Pendleton, Oregon, designed and constructed a complete harvesting system consisting of 1. an optical sensor for measuring grain protein on a combine harvester, 2. an electrical/mechanical device for physically segregating grain into low or high quality on a combine during harvest, and 3. software for calculating the best economic point at which to segregate grain into two bins. A test of the system was undertaken to determine if segregating hard red spring wheat into two bins was more profitable than conventional bulking into one bin. Results showed that segregation consistently increased the value of each bushel of grain when field-average protein concentration fell below a given price point on a stepped price schedule. Net returns from segregating wheat were up to $9.32 per acre greater than bulking into a single bin during years with large market price spreads and above average yields. Growers are now equipped with tools for evaluating the potential profitability from grain segregation during economic conditions when grain segregation may be profitable, thus improving the potential for economic viability of wheat farmers.

**Decision aid for comparing rental agreements.** Agricultural producers are faced with a variety of cropland rental options, such as cash rent, share rent, and flexible cash rent. ARS researchers at Auburn, Alabama developed a decision tool for comparing different cropland lease agreements, including flexible cash rents, for up to five crops and/or management systems. Flexible cash rents allow tenants and landowners to share the risk associated with uncertain commodity prices and yields. With the Cropland Rental Tool (CROPRENT), users can explore how different lease agreements impact their operation based on production expenses and price and yield data. This tool can be used for a variety of commodities regardless of geographic location and by a diverse audience, including Extension educators, landowners, and tenants. The Cropland Rental Tool is downloadable for free, with the accompanying User Manual, from http://www.cottoninc.com/fiber/AgriculturalDisciplines/AgriculturalEconomics/Cotton-Farming-Decision-Aids.

## Component 3. Production System Effects On Natural Resources

**"Blind" test of twenty-four corn growth simulation models reveals huge range of water use predictions.** To simulate the growth of corn, growth models must predict water use rate of the plants to account for the number of days of growth that can occur following a rain or irrigation event before the soil water supply is exhausted. As a contribution to the international Agricultural Model Inter-comparison and Improvement Project (AgMIP), an inter-comparison test was organized using eight years of water use (evapotranspiration or ET) measurements collected by an ARS researcher at Ames, Iowa. An ARS collaborator at Maricopa, Arizona, compiled initial "blind" (meaning that the modelers received no prior growth or water use information) ET predictions from 24 models run by 16 research groups around the world (including ARS researchers at Maricopa, Arizona and Beltsville, Maryland). The predicted numbers were found to vary by almost a factor of four and many of the predictions differed greatly from measured water use. This test conclusively identifies a weakness of many crop growth models, thus verifying a need for focused research to improve crop water representations for simulations using crop models. Ultimately, when errors estimating crop water use are corrected, the models will be used to improve management and policy decisions by stakeholders ranging from producers to strategic decision makers.

**Novel and inexpensive hoe for weeding near plastic covered strawberry and vegetable beds.** Controlling weeds along plastic mulch covered beds is extremely difficult because rigid blades of standard hoes can easily tear the plastic. An ARS researcher in Salinas, California developed a lightweight, adjustable and flexible bladed hoe made from 100% recycled material that efficiently slices through weeds but not plastic mulch. This 'recycle strap hoe' was a major breakthrough in weed management in cover-cropped furrows that are being promoted to conserve soil and reduce winter runoff in strawberry fields. The hoe also works well for hand-weeding vegetables without plastic mulch. This novel hoe was rapidly adopted by small-scale farmers in California and Hawaii, and has broad application world-wide for plastic mulch covered beds that are typically used for high value vegetables and berry production.

**Soil phosphorus composition is affected by agricultural system complexity.** Integrated crop-livestock systems are gaining traction as a potential method of sustainable agriculture intensification, leading to a need for clarification of nutrient cycling in these mixed systems. An ARS soil scientist in Raleigh, North Carolina, teamed with a group of scientists from the Federal University of Parana, State University of Santa Catarina, and Federal University of Rio Grande do Sul in Brazil to analyze soil for different fractions of phosphorus. At four sites in the Brazilian states of Parana and Rio Grande do Sul, cropping systems with greater complexity (with cattle grazing of cover crops or in an agroforestry system) led to surface soil concentration of plant-available orthophosphate and lower concentration of organically derived phosphorus components. The results of this research suggest that more complex cropping systems with livestock and trees could be valuable approaches to (a) enhance phosphorus cycling and (b) mitigate losses of phosphorus to the environment to promote global security with limited phosphorus reserves.

## Component 4. Integration of Sustainability Goals

**Long Term Agroecosystem Research (LTAR) network rangeland wind erosion research and model calibration.** Wind erosion from rangelands degrades soil productivity, causes highway fatalities from reduced visibility, creates human health problems, and causes abrasive damage to infrastructure. The lack of data on rangeland wind erosion has limited progress of basic science on the topic, development of simulation models needed to understand the consequences of management actions for rangeland erosion, and development of effective management options for reducing rangeland soil erosion. Working within the LTAR network, ARS scientists in Las Cruces, New Mexico coordinated the installation of wind erosion monitoring sites at three LTAR network locations. Installations at four other LTAR sites are planned to be operational during 2017. Instruments at the three completed sites are now collecting a suite of measurements (e.g., sediment mass flux, meteorological conditions, and dust deposition) with automated real time relay of the data to researchers. The long-term study of wind erosion on multiple ecological sites across the western U.S. will provide a data needed to assess the effects of land management and land use on rangeland wind erosion, thus providing insights needed to reduce the problem.

**National assessment of crop diversity.** The potential vulnerability of U.S. production to catastrophic events from an increasingly homogenous U.S. cropping system has been raised from anecdotal accounts of declining crop diversity. An analysis of U.S. crop diversity using actual data has been lacking, thus precluding credible assessment and formulation of a response, if needed. ARS scientists in Mandan, North Dakota and Morris, Minnesota, with collaborators at North Dakota State University and Kansas State University, used National Agricultural Statistics Service (NASS) data to evaluate changes in crop diversity at the county level across the U.S. Results showed that national crop diversity has declined over the past 34 years, with more counties shifting to lower diversity than to higher diversity. Crop diversity notably declined in counties adjoining the Corn Belt. However, regional variations are evident as some areas, for example central North Dakota and coastal South Carolina, increased crop diversity. This study establishes a benchmark for assessing the vulnerability of U.S. production and provides a metric on the sustainability of U.S. production systems needed by strategic decision-makers addressing the resilience of U.S. agricultural systems.

**Invasive species outcompete native species by the second week of growth.** Plant invasions of exotic species can cause losses of native species and lead to losses of ecosystem services. Ecologists have studied for decades which plant characteristics differ between natives and invasives, and if those characteristics can be used to predict invasiveness. Johnsongrass [*Sorghum halepense (L.) Pers*.] was introduced to the U.S. in the early 1800s for forage and has invaded native ecosystems, displacing native species. Johnsongrass invasion success appears to be caused in part by an ability to gain an early growth advantage over similar native grasses. To determine whether this was true, ARS scientists in Temple, Texas compared the factors promoting rapid growth in Johnsongrass and three native grasses. The results show that Johnsongrass gains a growth advantage over native species by the second week of seedling growth, and that this advantage is reinforced by reduced susceptibility to the effects of limited nutrient effects on growth, and more rapid development of traits needed to ensure continued growth advantages. These characteristics likely contribute to Johnsongrass invasiveness in native grass-dominated communities. Understanding the traits conferring invasiveness on Johnsongrass and other invasive exotic plants will help in identifying the critical timing for control measures.

**New tools for scientific information dissemination.** Relevant literature is necessary to conduct meaningful research, identify appropriate land management techniques, and build on—rather than duplicate—previous efforts. JournalMap was developed by ARS scientists in Las Cruces, New Mexico to advance the ARS mission to develop and transfer appropriate solutions to agricultural problems in the U.S. and throughout the world. JournalMap is the first true map-based search engine for scholarly publications and has expanded the ability of the scientific community to quickly and easily locate information in scientific literature relevant to specific study locations. JournalMap has continued to receive interest from researchers and the publishing industry. New agreements have been established with publishers and scientific societies to geographically index manuscript content, resulting in the release of a new version of JournalMap with improved search capability. JournalMap has ignited a movement within the scholarly publishing community to capture and use location information as a fundamental component of knowledge discovery and application. This search engine enables scientists to locate relevant research results for specific or similar locations worldwide, avoid duplication of efforts and assist with the identification of new analytical methods. JournalMap creates a major boost to the efficiency of literature searches worldwide.

**Projections of climate change effects on East Coast seaboard crop yields.** Projected climate change impacts on agriculture vary by crop and location. Understanding these impacts at a sub-regional scale is needed to develop adaptation strategies. ARS researchers in Beltsville, Maryland, used SPUDSIM and MAIZSIM crop growth and yield simulation models with soil, management, and climate data to simulate how potato tuber yields and corn silage might be impacted by a changing climate at the sub-county level of the northeastern seaboard region. The results showed a potential 50% reduction of potato yield and a potential 19% loss of corn silage if no adaptation measures are implemented. These impacts were comparatively larger in northern states than southern states, due in large part to warming temperatures and dryer, less humid air used with the climate predictions. The results provide an initial assessment of climate impacts on two important crops and can be used by scientists and policy planners to optimize distribution of the current production system under future climates.

**Long-term field management database**. There is great interest in the ability to mitigate water quality problems through changes to agricultural management. Long-term watershed and farm management datasets are a unique resource serving the research, management and policy arenas, but they are difficult to develop because they must protect the privacy of farmers and land owners without sacrificing the spatially and temporally specific nature of the data. ARS researchers in University Park, Pennsylvania developed a novel framework for recording land management, water quality and related data that expands the utility of these datasets across the research community and offers a model for other database management efforts. The initial database populated into the framework contains long-term field management information for fifteen farms and nearly 300 fields within a long-term experimental watershed located in a non-karst portion of Pennsylvania’s Ridge and Valley Physiographic Province. This database supports research aimed at helping farmers meet long-term production, land stewardship, and water quality goals and is expected to help with future development of options for management strategies.

## Component 5. Closing the Yield Gap through Interactions of Genetics x Environment x Management (G x E x M)

**High temperature impacts on corn hybrids.** Projections of the impact of high air temperatures have rarely been evaluated with observations to quantify crop response across different genetic material. ARS researchers at Ames, Iowa evaluated the effect of exposing three corn hybrids to high temperatures on the rate of growth and grain yield using a controlled-environment experiment. All three hybrids showed a faster rate of growth and a large reduction in grain yield when grown under higher air temperatures expected to occur by the end of this century. The most significant air temperature factor affecting grain yield was exposure to high nighttime temperatures during the grain-filling period. These results characterize crop yield responses needed for the development of adaptation practices for continued crop production.

**Improved classification of soils for precision farming.** Traditional crop management methods account for little of the within-field variation affecting crop production -- a basic need for the successful implementation of precision farming strategies. ARS researchers at Columbia, Missouri, and collaborators developed and tested the performance of a new soil classification system called “Environmental Response Units” (ERU) by examining how well it accounted for yield variation within farmers’ fields compared to publically-available USDA soil maps (Soil Survey Geographic Database or SSURGO). When compared on over 400 farmers’ fields in four Midwest U.S. states, the ERU classification accounted for more yield variation on average and gave better results in 86% of the fields when used to define within-field management zones. Soil classification with ERU soil maps better delineates soil and landscape characteristics within fields and can better guide the use of precision agriculture variable rate technologies. Farmers will benefit from this research as it can help them optimize their seed and fertilizer inputs to match production potential within fields. Matching input applications to a better-characterized soil resource reduces improves efficiency and minimizes field losses of agrichemicals, thereby benefitting society by contributing to cleaner lakes and streams.

**Evaluation of nitrogen decision tools for corn.** Many decision support tools are now available to help manage nitrogen (N) fertilizer applications, but corn farmers are often uncertain which tools work best in their specific conditions. ARS researchers at Columbia, Missouri, cooperators at numerous Midwest land-grant universities, and industry partners worked together to review crop reflectance sensor decision rules for N management. They found that the sensors could provide an in-season prediction of yield potential and crop N response but that additional information on growing conditions was also needed to optimize N fertilizer recommendations. Corn N fertilization recommendations based on canopy reflectance sensing were directly compared to N fertilization based on crop growth modeling using field data. Although the N rate prescribed by model-based approaches was closer to the recommended optimal N rate, recent versions of reflectance sensor-based decision rules appear to be closer to matching model-based recommendations. Farmers benefit from this research because they can reduce excess N applications and costs by varying fertilizer applications within a field. If fertilizer can be better matched with crop need, N fertilizer loss to the environment will be reduced and inputs costs of production may be reduced, thus helping to protect soil, water, and air resources while increasing net economic gains for producers.