FY2015 Annual Report
National Program 212 –Soil and Air

Introduction

National Program (NP) 212, Soil and Air, conducts research to improve the quality of atmosphere and soil resources that both affect and are affected by agriculture, to understand the effects of climate change on agriculture, and to prepare agriculture for adaptation to climate change.

Agricultural systems function within the soil-atmosphere continuum. Mass and energy exchange processes occur within this continuum and agriculture can significantly affect the processes. Emissions from agriculture to the atmosphere affect air quality and increase atmospheric greenhouse gas (GHG) concentrations. While GHG emissions result from the natural cycling of carbon (C) and nitrogen (N), these emissions also contribute to climate change. A changing climate impacts agriculture, range and pasture systems, and soils through alterations in precipitation and temperature patterns, and increased atmospheric carbon dioxide (CO_2) concentration. The impacts of climate change create challenges to agriculture and its soil resources, and also offer new opportunities for agricultural production and enhancement of soil quality.

Soils are a crucial boundary resource for agriculture and the atmosphere. Soils in agricultural systems must be managed to meet rising global demands for food, feed, fiber, fuel and ecosystem services while maintaining soil productivity and limiting undesirable interactions between soils and the atmosphere.

The variability of the atmosphere, soils, and plants, and the complexity of interactions among these systems require collaborations by ARS scientists conducting NP212 research. Formal and informal Cross Location Research (CLR) projects including the Greenhouse gas Reduction through Agricultural Carbon Enhancement network (GRACEnet), Resilient Economic Agricultural Production (REAP), and field campaigns focused on air quality and remote sensing of soil moisture are successful examples. Synthesis and integration of information, including sources outside NP212, by CLR projects increases the utility and impact of ARS research. Efficient assimilation of data from NP212 projects into existing and future collaborative data bases will enhance synthesis and integration analyses and expand research opportunities.

During FY 2015, 88 full-time scientists working at 25 locations across the U.S. were actively engaged in 36 ARS-led and 132 cooperative research projects in NP212. ARS-lead projects were approved through the ARS Office of Scientific Quality Review in late 2010, making this the fifth year of implementation of these five-year projects. The gross fiscal year 2015 funding for NP212 was $47 million.

Personnel News for NP212

- **Drs. Lew Ziska** of the Crop Systems and Global Change Laboratory, Beltsville MD, and **Jorge Delgado** of the Soil Management and Sugarbeet Research Unit, Ft. Collins, CO, served as Acting National Program Leader (NPL) for NP212 in FY15. Their excellent performance in this position is greatly appreciated.

New additions to the NP212 team in 2015 are*:*

- **Dr. Marlen Eve** arrived at ARS's Office of National Programs in August 2015 to begin his new position as the NPL for NP 212.
- **Dr. Shawn Christensen** was hired as a Research Plant Physiologist in the Chemistry Research Unit, Center of Medical, Agricultural and Veterinary Entomology, Gainesville, FL, after completing postdoctoral work in the research unit. Shawn studies plant defenses in maize against insect and fungal attack as well as the impact of climatic change on those defenses.
- **Dr. Alisa W. Coffin** joined the Southeast Watershed Research Laboratory, Tifton, GA from Colorado, where she owned of a private consulting business. Her expertise as a Research Ecologist is in GIS, remote sensing, and landscape ecology.
- **Dr. Mucahit Karaoglu** of Igdir University, Turkey was a visiting scientist at the Wind Erosion and Water Conservation Research Unit, Lubbock, TX, working with Dr. Scott Van Pelt. They are investigating factors controlling soil redistribution in rangeland agro-ecosystems. Dr. Karaolu's research was sponsored by the Scientific and Technological Research Council of Turkey (http://www.tubitak.gov.tr/en).
- **Dr. Lidong Huang** from the College of Applied Meteorology at the Nanjing University of Information Science and Technology in China was a visiting scientist at the Poultry Production and Product Safety Research Unit in Fayetteville, AR in 2015. Dr. Huang worked on a paired watershed and small plot study which evaluated the long-term effects of alum-treated and untreated poultry litter on phosphorus runoff and leaching.
- The National Laboratory for Agriculture and the Environment, Ames IA hosted two visiting scientists in 2015. **Dr. Tayfun Korucu** of Kahramanmaraş Sutcu Imam University, Kahramanmaraş, Turkey, was a visiting scientist in the National Laboratory for Agriculture and the Environment, Ames IA, working on a drainage tile line surface intake project as well as on a project to assess the effects of a rye cover crop and corn stover harvest on the quality of surface runoff. **Dr. Cassio Tormena**, Brazil, worked on the Visual Evaluation of Soil Structure (VESS) and Least-Limiting Water Range (LLWR) technologies for sustainable biomass feedstock production.
- **Dr. J. Gonzalo Irisarri** from Cátedra de Forrajicultura, IFEVA, Facultad de Agronomía, Universidad de Buenos Aires, CONICET joined the Rangeland Resources Research Unit, Cheyenne, WY, as a visiting scientist in 2015. Dr. Irisarri's research used long-term data to produce a publication on grazing intensity

regulating ANPP response to precipitation currently in press with *Ecological Applications*.

- **Dr. Donghui Xie** of the Beijing Normal University, was a visiting scientist at the Hydrology and Remote Sensing Laboratory, Beltsville, MD, working on crop phenology mapping using a remote sensing data fusion approach.
- The Soil & Water Management Unit, St. Paul, MN welcomed **Dr. Tae Jun Lim**, a visiting scientist from South Korea Rural Development Administration, Horticultural & Herbal Crop Environment Division, Suwon, South Korea. Dr. Lim's area of research is alterations in soil hydraulic properties following biochar additions.
- The Northwest Sustainable Agroecosystem Research Unit, Pullman WA, welcomed the following in 2015: **Dr. Sujith Ravi, a** visiting scientist from Temple University with expertise in geomorphology; **Dr. Jiangou Zhang,** a visiting scientist from Northwest Agriculture and Forest University in Yangling, China with expertise in soil ecology; **Dr**. **Ping Yan**, a visiting scientist from Beijing Normal University in Beijing, China with expertise in geomorphology; and **Dr. Zhongju Meng**, a visiting scientist from Inner Mongolia Agriculture University in Huhhot, China with expertise in soil science, and **Dr. Kadar Koirala**, a post-doc from Washington State University with expertise in GIS applications and statistics.
- The Soil & Water Management Unit, St. Paul, MN also added a new post-doc in 2015. **Dr. Florence Breuillin-Sessoms** recently graduated from the University of Fribourg, Switzerland, and is collaborating with the unit on quantifying the impact of microbial DNA dynamics on nitrification and N_2O production in fertilized soil.
- **Dr. Soledad Benitez** began an appointment as a post-doctoral Research Biologist at the North Central Agricultural Research Laboratory in Brookings, SD. She is working with Dr. Michael Lehman to determine how cover crops promote soil arbuscular mycorrhizal fungi and the crop production benefits they produce, especially reducing the need for phosphorus fertilizer and increasing crop utilization of soil micronutrients. Dr. Benitez is originally from Ecuador and earned her PhD from the Ohio State University.
- **Dr. Bernardo Chaves Cordoba** is a new postdoctoral research associate from Washington State University who has joined the Grain Legume Genetics and Physiology Research Unit in Prosser, WA, and is working with Dr. Rick Boydston and Dr. Lyndon Porter on developing climate resilient crop systems through GxExM.
- **Dr. Cristiane Pilon** has recently joined the Poultry Production and Product Safety Research Unit in Booneville and Fayetteville AR as an ORISE Post-doctoral Research Associate. Her research will focus on how grazing management and buffer strips affect soil erosion and nutrient and pathogen runoff from pastures. Dr. Pilon recently graduated from the Crop, Soil and Environmental Sciences Department at the University of Arkansas.
- **Dr. Patrick Nash,** who recently earned his PhD from the University of Missouri, has joined the Soil and Water Conservation Research Unit, Pendleton, OR as a post-doc.

His research will focus on determining the effect of climate change and management on soil carbon stocks at many sites around the nation as a part of GRACEnet.

- **Dr. Li Ma** joined the U.S. Salinity Laboratory, Riverside, CA, as a postdoctoral research associate. Dr. Ma will be studying the analytical and organic chemistry of antibiotic chemicals.

The following scientists retired from the ranks in NP212:

- **Dr. N. Andy Cole,** Research Animal Scientist, Research Leader of the Livestock Manure Management Research Unit, and Laboratory Director of the Conservation and Production Research Laboratory, Bushland, TX. Dr. Cole continues to collaborate on research via NIFA Grazingland CAP grant.
- **Dr. Ted M. Zobeck** of the Wind Erosion and Water Conservation Research Unit, Lubbock, TX, after 32 years of service with ARS. He now lives in Rockdale, TX

The distinguished record of service of these scientists is recognized world-wide, and they will be missed in NP212.

The following scientists in NP 212 received prominent awards in 2015:

- **Dr. Jane Johnson,** of the Soil Management Research Lab in Morris, MN, received the Civil Servant of the Year Award for 2015 from the Federal Executive Board of MN, in recognition of extraordinary service to the community and government.
- **Dr. Rod Venterea** of the Soil & Water Management Unit, St. Paul MN, was named a Fellow in the Soil Science Society of America.
- **Dr. Gilbert C. Sigua** of the Coastal Plains Soil, Water, and Plant Research Center, Florence, SC was named a 2015 Soil Science Society of America (SSSA) Fellow for his outstanding research and technical contributions in enhancing agricultural and environmental sustainability and improving functionality of degraded soils for environmentally sustainable production in humid region.
- A team of ARS scientists in Florence, SC (**Drs. Keri Cantrell, Patrick Hunt, Jeff Novak** and **Kyoung Ro**) and in New Orleans, LA (**Dr. Minori Uchimiya**) received the 2015 Best Paper Award as co-authors of an article published in Bioresource Technology entitled “Impact of pyrolysis temperature and manure source on physiochemical characteristics of biochar.” This article was cited over 150 times in only a few years of publication.
- **Dr. Scott Van Pelt** of the Wind Erosion and Water Conservation Research Unit, Lubbock, TX, was presented the Conservation Research Award by the Soil and Water Conservation Society. Dr. Van Pelt also hosted the 18th Congress of the International Soil Conservation Organization in 2015, in El Paso, TX.

- **Dr. Jorge A. Delgado** of the Soil Management and Sugar Beet Research Unit, Ft. Collins, CO received the "2015 Best Research Paper Award for Impact and Quality, Honorable Mention", which "recognizes the impact and quality of research paper published in the Journal of Soil and Water Conservation in the previous five years." Dr. Delgado also received the American Society of Agronomy (ASA) Werner L. Nelson Award for Diagnosis of Yield-Limiting Factors, for "creativity and innovation of the nominee's involvement in the development, acceptance, and/or implementation of diagnostic services in higher, more profitable crop production."
- **Dr. Jerry Hatfield** of the National Laboratory for Agriculture and the Environment, Ames IA, received the American Society of Agronomy President's Award for his contributions to the Agricultural Model Intercomparison and Improvement Project (AgMIP).
- **Dr. Doug Karlen** of the National Laboratory for Agriculture and the Environment, Ames IA, received the Soil and Water Conservation Society's Hugh Hammond Bennett award for National and International Leadership in Natural Resource Conservation. Dr. Karlen also received the 2015 ARS Distinguished Senior Research Award for outstanding leadership and research accomplishments in the areas of assessing soil quality and identifying soil and crop management practices that can be utilized to provide sustainable bioenergy feedstock supplies.
- **Dr. Scott Yates** of the U.S. Salinity Laboratory, Riverside, CA was inducted into the ARS Hall of Fame.

The quality and impact of NP 212 research was further evidenced in 2015 by the following:

- 164 refereed journal articles published
- A new patent application and nine new invention disclosures submitted
- Two current cooperative research and development agreements and nine new material transfer agreements with stakeholders

In 2015, NP 212 scientists participated in research collaborations with scientists in: Argentina, Australia, Brazil, Canada, Chile, China, Colombia, Congo (Democratic), Costa Rica, Denmark, Ecuador, Egypt, Finland, France, Germany, Ghana, India, Indonesia, Ireland, Italy, Japan, Jordan, Korea (South), Malawi, Mali, Marshall Islands, Mexico, Namibia, Netherlands, New Zealand, Norway, Peru, Poland, Saudi Arabia, South Africa, Spain, Sweden, Switzerland, Turkey, United Kingdom, and Uruguay.

Significant Accomplishments for FY2015

This section summarizes significant and high impact research results that address specific components of the FY 2011 – 2015 action plan for NP 212. Each section summarizes accomplishments of individual research projects in NP 212. Many of the programs summarized for FY 2015 include significant domestic and international collaborations with both industry and academia. These collaborations provide extraordinary opportunities to leverage funding and scientific expertise for USDA - ARS research by rapidly disseminating technology, which enhances the impact of ARS research programs. This National Program is organized into four components:

1. Enable Improvements of Air Quality via Management and Mitigation of Emissions from Agricultural Operations
2. Develop Knowledge and Technologies for Reducing Atmospheric Greenhouse Gas (GHG) Concentrations through Management of Agricultural Emissions and Carbon (C) Sequestration
3. Enable Agriculture to Adapt to Climate Change
4. Maintaining and Enhancing Soil Resources

Component 1: Enable Improvements of Air Quality via Management and Mitigation of Emissions from Agricultural Operations

Atmospheric emissions from agriculture are under increased scrutiny due to potential negative environmental effects and threats to human and animal welfare. Emissions contribute to tensions between agriculture and residential communities with visibility impairment (haze) and nuisance odors. Major classes of emissions include particulate matter (PM), volatile inorganic compounds (primarily ammonia and hydrogen sulfide), volatile organic compounds (VOCs), and those from pesticides. Often these emissions exist as mixtures and, thus, adjustments to production practices for abatement may decrease the release of one material while changing the emission character or magnitude of other materials.

Selected FY15 Accomplishments:

A newly-registered bacterial bioherbicide for the treatment of persistent annual grass weed species. This represents the first bacterial bioherbicide to be registered by the Environmental Protection Agency (EPA). Downy brome (cheatgrass), medusahead rye, and jointed goatgrass are invasive annual grass species that cause an increase in the number and intensity of wildfires; reduce cereal yields; compete with native plant species; and reduce the quality of habitat for wildlife. Naturally occurring soil bacteria inhibit these annual grass weeds, but do not harm crops or natives. ARS scientists at Pullman, Washington, isolated bacteria that reduce these three grass weeds to near zero within 5 years and reduce the weed seed bank, when used in an integrated program. The EPA has registered one of the bacteria as an herbicide and is considering a second. This provides an additional tool to private, state and federal land managers to fight these invasive grass weeds, while limiting the need for tillage and herbicide use, thus reducing environmental concerns as well. This research development has gained considerable attention from both federal land management agencies and the press. (Links of interest: http://www.fws.gov/refuges/news/ManagingCheatgrass.html; http://beefmagazine.com/new-biological-herbicide-can-control-cheatgrass)

Nitrous oxide (N_2O) emissions and perennial vegetation filter strips. Nitrogen use in agricultural systems can result in emissions of nitrous oxide (N_2O), a greenhouse gas, and in nitrate (NO_3) contamination of ground and surface waters. ARS scientists in Ames, Iowa studied the use of perennial vegetation filter strips in the toe-slope of annual cropland watersheds, and found that these can be used to decrease NO_3 losses to ground and surface waters via plant uptake, immobilization into soil organic matter, and microbial denitrification. Denitrification was the predominant NO_3 sink, accounting for approximately 70% of NO_3. Although denitrification was stimulated, less N_2O was emitted than from upland cropland. These results suggest that the greater amount of potentially mineralizable carbon (C) in filter strips supports more complete denitrification of NO_3 to nitrogen (N_2) gas. In a separate chronosequence study investigating inter-seeded alfalfa and fluxes of N_2O and methane (CH_4), ARS scientists found that while alfalfa can increase soil N and improve productivity, trace gas emissions were not increased relative to native grasslands. This research helps land managers keep and utilize nutrients on their properties, increasing production while providing an environmental service that can result in improved water quality and reduced GHG emissions. (Links of interest: http://www.desmoinesregister.com/story/money/agriculture/2015/04/10/water-quality-conservation-efforts/25606355/; https://efotg.sc.egov.usda.gov/references/public/IA/Saturated_Buffer_739_FS_2015_01.pdf)

Converting red clover to annual crops without tillage in organic farming. Organic producers would like to reduce their level of tillage to protect soil health, but they are concerned about controlling weeds without tillage. ARS scientists at Brookings, South Dakota determined that red clover, a perennial legume, can be used in rotation and then converted to annual crops without tillage, using a fall mowing strategy. The tactic reduced weed emergence in corn more than 85%, also delaying time of weed emergence. Organic producers can now include a 3-year interval of no-till into their farming systems if red clover is included in the rotation. Organic producers modifying their rotations to include a 3-year interval of perennial legumes are reducing tillage and improving soil health while improving weed control in their farming operations. (Link of interest: https://andyhowardnuffield15.wordpress.com/2015/06/25/dr-randy-anderson-ars-brookings-south-dakota-24th-june-2015/)

Component 2: Develop Knowledge and Technologies for Reducing Atmospheric Greenhouse Gas (GHG) Concentrations through Management of Agricultural Emissions and Carbon (C) Sequestration

Agriculture GHG emissions to the atmosphere are among the documented anthropogenic factors driving climate change. Land management practices may be altered to reduce GHG emissions. Agriculture also provides an opportunity to sequester C in soils, thus offsetting GHG emissions and offering a partial solution to slowing the forces of climate change. Increasing production without increasing emissions also presents an opportunity to decrease the emissions intensity of certain agricultural commodities.

Selected FY15 Accomplishments:

Fertilizer application timing influences greenhouse gas emissions. Increasing crop production while reducing emissions of nitrous oxide (N_2O) and other greenhouse gases requires careful management of nitrogen fertilizers. ARS scientists at Pendleton, Oregon, measured N_2O emissions when fertilizer was applied to winter wheat at seeding versus in-season, when plants are growing and nitrogen uptake is high. Fertilizer timing was found to affect emissions substantially, with greater N_2O emissions for wheat fertilized at seeding. In addition to contributing to the buildup of greenhouse gases in the atmosphere, the N_2O emissions also represent a loss of expensive nitrogen inputs from the production system. Fertilizer application during the growing season resulted in substantially less N_2O emissions and improved nitrogen utilization by the crop, making this a potentially useful fertilization strategy for dryland wheat production systems in the Pacific Northwest. This information is important in our efforts to increase crop production while reducing environmental impacts such as GHG emissions.

New technical tool to quantify environmental services. USDA Technical Bulletin 1939, titled, "Quantifying Greenhouse Gas Fluxes in Agriculture and Forestry: Methods for Entity-Scale Inventory," was published in late FY14 with many ARS scientists from several locations contributing as author/experts. In FY15, ARS scientists at Fort Collins, Colorado worked with NRCS and Colorado State University to integrate the guidance in the report into the COMET-Farm online tool for assessing the greenhouse gas impact of agricultural management practices, enhancing the tool's usefulness for land managers, greenhouse gas registries, state and federal agencies, and other USDA stakeholders. The ARS involvement in this effort has contributed to the scientific rigor and transparency of the tool that may help equip land managers with knowledge and understanding needed to enter into markets for environmental services. (Links of interest: http://ethanolproducer.com/articles/11334/usda-report-aims-to-provide-uniform-method-for-ghg-assessment; http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/home/?cid=STELPRDB1119532; http://plantingseedsblog.cdfa.ca.gov/wordpress/?p=9919)

Development of adaptation strategies to reduce the impact of climate change. ARS scientists at locations across the U.S. worked collaboratively with the USDA Regional Climate Hubs to develop region-specific, science-based assessments of the climate change mitigation opportunities and adaption challenges of agricultural production systems within each region. In one example, analysis of climate data was conducted to develop a climate atlas in support of the adaptation and mitigation efforts of the Midwest Region Climate Hub. These analyses included precipitation, maximum and minimum temperatures, and average temperatures for the period from 1895 through 2013. Spring (April-June) and summer (July-September) rainfall were measured relative to the annual total, revealing that annual spring rainfall is increasing while summer rainfall is decreasing. This is resulting in a reduced number of workable field days in the spring and increased potential for water deficits in the summer across the Midwest. Additional analyses showed that excessive soil moisture and drought are significant sources of crop loss across the region. This information is important as researchers develop new management systems to help producers in the Midwest manage crop production under changing climate. (Links of interest: http://blogs.usda.gov/2015/09/22/helping-farmers-adapt-to-a-changing-climate-through-regional-vulnerability-assessments/#more-60709); http://blogs.usda.gov/2015/12/04/five-things-you-should-know-about-usda-climate-hubs-in-2015/)

Measuring soil carbon by inelastic neutron scattering. Soil carbon plays a critical role in soil fertility and farm productivity, and is important for water/nutrient retention, good soil structure, and maintenance of clean water through erosion prevention. Further, carbon capture from the atmosphere by plant growth helps mitigate global climate change through soil carbon storage. Measurement of soil carbon remains a time-consuming and laborious practice. ARS scientists in Auburn, Alabama developed a new *in situ* rapid, non-destructive method of measuring soil carbon (mobile inelastic neutron scattering, MINS). MINS has been tested and compared to the standard dry combustion method. Soil carbon assessments by dry combustions and MINS demonstrated a linear correlation in the 0-30 cm soil layer, indicating that MINS produces reliable soil carbon measurements. This new tool allows soil scientists to more rapidly quantify carbon storage in agricultural soils, helping land managers evaluate best management practices, improve soil health, and mitigate climate change. (Links of interest: https://www.researchgate.net/publication/274058358_Field_Testing_a_Mobile_Inelastic_Neutron_Scattering_System_to_Measure_Soil_Carbon; http://www.sciencedirect.com/science/article/pii/S0969804315302402)

Beneficial fungi can improve nutritional quality of produce. Inoculation of vegetable crops with arbuscular mycorrhizal [AM] fungi can reduce the need for chemical inputs while increasing yields and farm economic sustainability. Young leek and pepper plants colonized by mycorrhizal fungi were extracted and analyzed for levels of polyphenols, compounds that are well known to benefit human health by ARS researchers at Wyndmoor, Pennsylvania. Concentrations of these compounds were compared to levels in uninoculated controls. There were clear increases in polyphenols in both leek and pepper shoots. This improved nutritional quality of produce due to inoculation with AM fungi, in addition to improved yield, gives an additional advantage to this sustainable practice at the market place.

Component 3: Enable Agriculture to Adapt to Climate Change

Mechanisms for adapting to climate change are critical for continued agricultural production and stewardship of natural resources. An understanding of the impacts of climate change on natural and managed ecosystems provides insights needed to formulate strategies for addressing vulnerabilities and exploiting potentially beneficial aspects of climate change. Mechanisms for identifying and detecting indicators of impacts are key to formulating management responses. Adaptive responses to climate change must be evaluated for impacts on ecosystem function and potential feedbacks on the climate system and subsequent consequences for sustainability and reinforcement, or offset of, climate change mitigation strategies.

Selected FY15 Accomplishments:

Ozone-responsive genes identified in soybean. Ground level ozone is formed by the action of sunlight on volatile hydrocarbons and nitrogen oxides produced during combustion of carbon based fuels. Although frequently considered an urban problem, ozone pollution is much broader in scope because weather systems transport the pollutants into agricultural areas. Ozone is an air pollutant that is toxic to plants, causing visible injury to foliage and a reduction in the growth and yield of sensitive crops such as soybean. Estimates suggest that current ambient ozone levels are sufficient to reduce soybean yield by 10-20% with greater yield losses anticipated if tropospheric ozone concentrations continue to increase. In the absence of successful efforts to control ozone pollution, future crop productivity may depend on the development of ozone-tolerant soybean varieties. ARS researchers at Raleigh, North Carolina and colleagues at the University of North Carolina at Charlotte conducted a comprehensive gene expression study that compared ozone-sensitive and tolerant soybean genotypes. Multiple genes were affected within the first hours of ozone exposure, including those associated with oxidative stress and leaf surface chemistry. Genotype differences in gene expression profiles were found. The results will be used to identify genes that could be manipulated to develop cultivars capable of maintaining yields under elevated ozone conditions. (Links of interest: http://phys.org/news/2015-11-ground-level-ozone-maize-soybean-yields.html)

Variation in photoperiod sensitivity requires reconsidering when and where to plant beans. The relative duration of daylight to nighttime, or "photoperiod", affects the time of flowering in dry bean (i.e., the species that includes kidney, navy, black, pinto and great northern types), but it has been suggested that modern cultivars have been selected to become less sensitive to photoperiod. Such a trend has important implications for ensuring that new cultivars are appropriately matched to environments and crop management, especially sowing dates. An ARS scientist at the Arid-Land Agricultural Research Center in Maricopa, Arizona, compiled and analyzed data from 665 cooperative dry bean nurseries from 1981 to 2014 to assess whether photoperiod sensitivity has indeed declined in recently released germplasm. For 59 cultivars with at least 25 field measurements and known years of official release, large variation in photoperiod sensitivity was found. However, there was no indication of loss of photoperiod sensitivity over time. This suggests that modern bean lines include a range of responses to novel environments or management conditions, including under possible warming trends, providing the ability to select bean germplasm that is well suited to different production regions.

Rising atmospheric carbon dioxide stabilizes forage production in a semiarid rangeland. The impact of climate change on semi-arid rangelands, which provide forage for the majority of the world's livestock, is likely to have a strong influence on human well-being. Research by scientists from ARS in Fort Collins, Colorado, Cheyenne, Wyoming, and the University of Wyoming, suggests that elevated carbon dioxide (CO_2) may have positive effects on the stability of forage production. A unique climate change experiment undertaken in native, semiarid rangeland at the High Plains Grasslands

Research Station near Cheyenne, Wyoming revealed that increasing the ambient CO_2 concentration from the present-day level of 400 parts per million (ppm) to 600 ppm decreased year-to-year variation in plant production, in part by increasing the abundance of less common plant species. Even with elevated CO_2, however, productivity was much lower in dry years, suggesting that if precipitation becomes more variable in the future, as predicted, it will still lead to wide swings in forage production. These results will be critical in helping agricultural scientists adapt management and genetic strategies for a changing climate. The results are also being used to improve and refine models and decision support tools. (Links of interest: http://www.bioone.org/doi/pdf/10.1016/j.rama.2015.07.007)

Component 4: Maintaining and Enhancing Soil Resources

Soil productivity must be enhanced to meet increasing global food, feed, fiber, and fuel demands. Soil degradation through erosion and decreased physical (e.g., structure, compaction, infiltration), chemical (e.g., acidification, salinization, nutrient depletion), and biological (e.g., biodiversity, nutrient cycling, soil organic matter) properties and processes must be mitigated to ensure critical goods and services provided by soil resources are maintained.

Selected FY15 Accomplishments:

Award winning soil test is helping producers optimize fertilizer application rates. Fertilizer application protocols must be carefully chosen, taking into consideration all sources of plant-available nutrients to ensure that fertilizer is applied at an optimal rate. Recent high-profile nutrient-related incidents, such as the algal bloom in Lake Erie— which is the City of Toledo's drinking water supply— have increased socio-economic pressure on farmers and ranchers to optimize nutrient application and management. ARS scientists at Temple, Texas have developed the "Haney Test", an award-winning soil test based on enhanced methodology that is quickly being adopted by major soil testing laboratories to determine optimal fertilizer application rates. In published field evaluations in Texas, fertilizer recommendations based on the Haney Test reduced nutrient losses, increased profit potential and decreased input cost and production risk. Use of the Haney Test has resulted in reduced fertilizer application rates, minimizing negative impact to air and water resources and reducing fertilizer costs by 20-40%. This tool is useful to agricultural producers who are attempting to increase profitability and sustainability, and to labs, consultants and land management agencies, who need sound science to support natural resource conservation. (Links of interest: http://www.thefencepost.com/news/15393857-113/sprouts-what-is-a-soil-health-test-and-why-should; http://blogs.usda.gov/2015/08/05/cover-crops-and-no-till-help-south-dakota-lamb-farmer/; http://www.agriculture.com/crops/fertilizers/soil-health-tool-shows-nutrient_174-ar46457; http://phys.org/news/2014-07-fertilizer-accurate-soil.html)

New assessment techniques and analyses for determining microbial community structure and function. Soil microbial communities carry out important ecosystem services such as soil aggregation, pathogen suppression, and nutrient cycling.

Identification and quantification of microbes and pathogens by traditional methods, such as culturing, is estimated to catalog as little as 1% of the microbial diversity in the soil, and is semi-quantitative at best. The complexity of these microbial communities means that traditional ecological indices may overestimate diversity (i.e., pseudo-diversity) as a result of incomplete community sampling. ARS scientists in Fort Collins, Colorado utilized molecular biology techniques to quantify microbial community structure and function from a variety of natural environments. The scientists conducted the first known application of pyrosequencing (a DNA analysis technique) to investigate root endophytes in an agricultural crop, leading to the discovery of a wide variety of previously unknown microbial species residing within the roots of crop plants. These analyses have led to the development of a new diversity index, and statistical software that can be used to remove pseudo–diversity, providing more accurate estimates of the true variation in microbial communities across various scales. This improved understanding of the soil microbial communities will allow better management for improved soil health and optimized crop production.

Reducing tillage increases crop water availability and saves fuel. A secure, resilient, and sustainable food supply requires continued progress toward ending soil erosion. The most common wheat production method in low-rainfall areas of the Pacific Northwest relies upon intensive tillage that leaves the soil susceptible to wind erosion. ARS scientists at Pendleton, Oregon, measured the effects of surface residue and soil tillage on the amount of soil moisture available for crop growth. It was found that, with careful timing, reductions in tillage and an increase in surface residue often increase water available to the crop. The result is equal or better wheat yields with greater weather resilience and much less exposure to wind and water erosion. Additionally, an average reduction of two tillage passes on 4 million acres of low-precipitation-zone wheat can save 1.75 million gallons of diesel fuel per year. Farmers are using this knowledge to reduce the number of tillage passes used in the crop cycle while maintaining yields, reducing vulnerability to soil erosion, increasing climate resilience, decreasing fuel costs, and reducing GHG emissions.

Cover crops support the beneficial activities of soil microorganisms. Increasing the numbers, diversity, and activities of beneficial microorganisms provides paybacks for crops in terms of fertility, drought tolerance, and pest protection. These benefits have near-term value, while improved soil health represents an investment in future productivity. ARS scientists in Brookings, South Dakota have shown that cover crops increase the numbers and diversity of beneficial arbuscular mycorrhizal (AM) fungi which supply nutrients (especially phosphorus) and water to their plant host. These AM fungi also protect the plant host from pathogens and pests. The researchers found that using forage oats as a fall cover crop was especially effective at promoting AM fungi, and that cover cropping boosts soil microbial biomass and potentially mineralizable soil nitrogen. This information is important to producers who wish to integrate cover crops into agricultural production systems, and help to more fully characterize the interactions between soil-dwelling AM fungi and crop plants. Building and maintaining complex soil microbial communities reduces the overall near-term requirement for inorganic fertilizers and pesticides while increasing the long-term production potential of the soil. (Links of interest: http://www.sdcorn.org/2015/11/what-is-mycorrhiza/; http://cornandsoybeandigest.com/conservation/soil-fungi-can-save-money-and-phosphorus-runoff)

Biochar increases available nitrogen from manure amendments. Amending soils with biochar, a byproduct of bio-oil production, could remove excess atmospheric carbon dioxide, while improving soil quality. ARS researchers at Kimberly, Idaho, and St. Paul, Minnesota, measured plant-available nitrogen and greenhouse gas emissions from plots treated with biochar and/or manure. Although biochar decreased carbon dioxide emissions from soil, it also decreased corn yields under particular soil conditions. Combining biochar with manure eliminated potential yield reductions from biochar while increasing nitrogen availability from manure. This is important information to producers who wish to apply biochar to achieve soil quality or environmental services goals while maintaining or increasing their yields.

Conservation management practices improve soil quality. The Salt River Basin in the Central Claypan Region of Missouri is challenged by marginal and degraded soils that are known for high runoff and soil erosion potential. ARS scientists at Columbia, Missouri, Ames, Iowa, and West Lafayette, Indiana assessed the benefits of conservation management practices using soils collected from management systems representing different types of grassland and a range of annual cropping systems. Soil quality was evaluated using soil chemical, physical, and biological measurements and the Soil Management Assessment Framework (SMAF) model was used to transform laboratory measurements into soil quality scores. Soil quality scores were highest for systems with permanent vegetative cover and living roots; among annual grain cropping systems, reduced tillage and incorporation of cover crops increased soil quality scores over systems using mulch-till and systems without cover crops. Based on the results of this study, the greatest soil quality benefits from the restoration of degraded or marginal soils would be realized with perennial systems including either cool- or warm-season grasses with legumes, followed by working grasslands and pasture systems. This study benefits producers, scientists, and policy makers by demonstrating the benefits of vegetative cover and living roots to surface soil quality, and by documenting the importance of diversified cropping systems that reduce soil disturbance, maximize soil cover, and potentially increase profitability. (Links of interest: http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_013267.pdf)