USDA-ARS National Program 216- Sustainable Agricultural Systems
Annual Report for FY2020

Introduction

Fiscal year 2020 research supported the 2018-2022 Action Plan for National Program (NP)216. The Action Plan and the projects were developed from comprehensive stakeholder input gleaned from national stakeholder listening sessions.

Vision

Integrated solutions for agriculture enabling greater productivity, profitability, and natural resource enhancement.

Mission

The mission of NP216 is to build the science-based foundations for farming systems of the future using a systems approach without bias for particular science discipline. Producers will be equipped with actionable genetic and management options offering multiple routes to achieving the four goals of sustainable agriculture: 1) desired quantity and quality of yields, 2) economic viability and competitiveness, 3) environmental enhancement, and 4) quality of life for rural populations and society as a whole.

This transdisciplinary research effort integrates information and technology. New configurations of practices will be identified that integrate on-farm resources with knowledge of natural ecosystem processes to reduce the need for purchased inputs, thus reducing production costs and risk. Technological advances that include precision management, automation, and decision support tools are investigated to increase production efficiencies and enhance environmental benefits. The resulting diverse, improved agricultural systems will support the long-term financial viability, competitiveness, and sustainability of farms and rural communities, and increase food, feed, and fiber security for the U.S. and the world.

Approach

NP216 is organized into three components:

- Building Agroecosystems for Intensive, Resilient Production via GxExM
- Increasing Efficiency of Agroecosystems
- Achieving Agroecosystem Potential

These three component areas focus on what can be implemented to improve production efficiency within the field, what can be done to limit the offsite impact and enhance ecosystem services, identify the limitations to productivity, sustainability, and resilience of agricultural systems, and integrate knowledge gleaned to optimize agricultural systems at the field and farm scale.

2020 News for NP216

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 2020, NP216 scientists participated in research collaborations with scientists from Argentina, Belgium, Brazil, Canada, Chile, China, Colombia, Denmark, Finland, France, Germany, Honduras, India, Italy, Japan, Kazakhstan, Mexico, Mongolia, Mozambique, Nigeria, Northern Ireland, Norway, Peru, South Korea, Spain, Switzerland, Taiwan, Turkey, United Kingdom, and Uruguay. In FY2020, 100 full-time scientists working at 27 research units across the U.S. actively engaged in 32 ARS-led and 150 collaborative research projects. Base program funding was $71M.

Personnel news for NP216

New additions to the NP216 team in 2020 were:

- **Dr. Peter O'Brien** joined the National Laboratory for Agriculture and the Environment, Agroecosystems Management Research, as an Agronomist. After receiving his Ph.D. at North Dakota State University, Peter started at NLAE as a postdoctoral Research Associate in 2018.
- The Southeast Watershed Research Lab in Tifton, GA welcomed the following new personnel in 2020: **Dr. Rachel Nifong** joined SEWRL as a Research Hydrologist. Dr. Nifong is a former ARS Post-Doctoral Associate who was assigned at the National Sedimentation Lab in Oxford, MS, and came to SEWRL from the U.S. Army Corps of Engineers where she served as a Biologist/Project Manager. Dr. Nifong earned her Ph.D. in Hydrologic Sciences at the University of FL in 2015. In addition to research on hydrologic processes, Dr. Nifong will be conducting research on the spatial and temporal aspects of water availability and links to trace gas fluxes in the southeastern coastal plain. **Dr. Kathryn (Katie) Pisarello** accepted a position as a Research Soil Scientist. Dr. Pisarello earned her Ph.D. in Soil and Water Sciences at the University of FL in 2019. She will be conducting research integrating crop, population biology, economic, watershed, ecosystem services, social and risk assessment models to quantify economic, environmental and production tradeoffs for the Gulf Atlantic

Coastal Plain LTAR site and will work with the LTAR Modeling Team to compare economic, environmental, and production tradeoffs among major crop production regions across the LTAR network. **Mr. Earl Keel** was hired as a Hydrologist; prior to this position, Mr. Keel was a Computational Biologist with the SEWRL. Mr. Keel will be providing oversight to the SEWRL's hydrologic and environmental studies and assisting in data processing. **Dr. Haile Tadesse** joined SEWRL as a Physical Scientist. Dr. Tadesse worked for the Environmental Protection Agency as a Postdoctoral Fellow in the ORISE program, and prior to that with ARS as a Physical Science Technician in El Reno, OK. Dr. Tadesse earned his Ph.D. in Environmental Science and Public Policy from George Mason University. He also holds a professional certification in Geographic Information Science from George Mason University. Dr. Tadesse will be supporting research on cropping systems and water use efficiency in the southeastern U.S. using remote sensing and GIS.

- **Dr. Yanbo Huang** joined the Genetics and Sustainable Agriculture Research Laboratory, Mississippi State, MS, as a Research Agricultural Engineer. Dr. Huang came from ARS at Stoneville, MS. His area of expertise is Artificial Intelligence and Machine Learning. The lab also welcomed a new Research Biologist, **Dr. Dewayne Deng**. Dr. Deng's area of expertise is Bioinformatics, Statistics, and Database Management.
- **Dr. Curtis Ransom** was hired as a Research Soil Scientist at the Cropping Systems and Water Quality Research Unit in Columbia, MO. Dr. Ransom received a Ph.D. from University of Missouri. His research will focus on Big Data, Artificial Intelligence, and machine learning for agronomic decision support.
- The Adaptive Cropping Systems Laboratory in Beltsville MD had several visiting scientists in FY20: **Dr. Sanai Li,** an Agro-meteorologist from China visited via U.S. Forest Service International Visitors Program. Dr. Li's focus is on improving simulation of rice growth and development under U.S. production conditions. These improvements will be used to study climate and resource impacts, and identify management and phenotypic adaptation strategies in the Mississippi Delta. **Dr. Wenguang Sun**, soil scientist, visited from China via University of Nebraska. Dr. Sun's focus is improvement of photosynthesis and transpiration components of the soybean model, GLYCIM. This will allow for more realistic assessment of soybean management consequences on soil quality and water use in crop production systems in the United States. **Dr. Sahila Beegum**, was another visiting soil scientist, from India via University of Nebraska. Dr. Beegum's focus is improvement of photosynthesis and transpiration components of the cotton model, GOSSYM. This will allow for more realistic assessment of cotton management consequences on soil quality and water use in crop production systems in the United States. **Dr. Sonal Mathur**, a plant physiologist, visited ACSL from India, via ORISE. Dr. Mathur's work evaluated soybean cultivars from all the maturity groups on flowering response to changes in day length and temperatures. These data will be used to develop response functions for our soybean model, GLYCIM. This will

improve soybean model's predictions at a range of environmental conditions and maturity groups. Finally, **Dr. Beomseok Seo**, plant physiologist, traveled from Korea via the University of Washington. Dr. Seo's work focused on soybean flowering experiments and model development along with Dr. Mathur.

- **Dr. Ken Wacha** was hired as a Research Agricultural Engineer at the National Soil Erosion Research Laboratory, West Lafayette, IN. Prior joining NSERL, Dr. Wacha was an ORISE fellow with National Laboratory for Agriculture and Environment (NLAE) at Ames, Iowa. He studies how management practices impact the delivery of ecosystem services, including soil physical quality/health, organic matter, surface hydrology and upland erosion.
- **Dr. Partson Mubvumba** joined the Crop Production System Research Unit in Stoneville, MS as a Research Soil Scientist in 2020. He received his Ph.D. from Texas A&M University and was serving as a Postdoctoral Research Associate at Texas A&M AgriLife Research in Vernon, TX before joining ARS. His area of expertise is on evaluation and management of soil ecosystems and soil water dynamics under different cropping systems.
- **Dr. Emile Elias**, a former postdoctoral research associate with the Jornada Experimental Range (JER), in Las Cruces NM, was hired as the USDA Southwest Climate Hub Director in 2020. Dr. Elias's expertise is in climate impacts on Southwest hydrology; she now leads the Hub's activities. JER also welcomed postdoctoral research associate **Dr. Erica Christensen**, Research Ecologist, from NMSU and University of Florida. She works on long-term vegetation dynamics and computational approaches to state and transition models for Ecological Site Descriptions.
- **Dr. Sadikshya Rana Dangi** joined the Agricultural Systems Research Unit, Sidney MT, as a Research Soil Scientist with expertise in soil microbiology.
- **Dr. Ali Srour** joined the New England Plant, Soil, and Water Laboratory, Orono, ME, as a postdoctoral research associate. Dr. Srour received his M.S. and Ph.D. degrees at Southern Illinois University; he will study interactions and relationships of the soil microbiome in association with crop management practices, soilborne disease suppression, and crop productivity in potato and organic vegetable production systems.
- **Dr. Garett Heineck** has joined the Grain Legume Genetics and Physiology Research Unit in Prosser, WA as a postdoctoral research associate. Dr. Heineck comes from the University of Minnesota and is working on identifying lentils with resistance to *Fusarium avenaceum*, a major root rot pathogen of lentil, and genes associated with resistance to the pathogen.

The following scientists left the ranks of NP216 in 2020:

- **Dr. Jerry Hatfield**, Director of the National Laboratory for Agriculture and the Environment, Ames IA, retired in 2020. Dr. Hatfield was well known as the first Director of NLAE and for his research on crop and soil water dynamics and environmental quality.

- **Mr. Alfredo Gonzalez**, Animal Scientist with the Range Management Research Unit in Las Cruces NM, passed away in 2020. Mr. Gonzalez introduced the Raramuri Criollo cattle type, a major component of the Jornada Experimental Range's LTAR program, to the United States. The breed has been adopted across the Western U.S. and is a basis for the recently funded NIFA SAS grant to NMSU/Jornada.
- The Columbia Plateau Conservation Research Center, Pendleton OR, said farewell to two retiring scientists in 2020: **Dr. John D. Williams and Dr. Dan Long.**
- **Dr. Cindy Cambardella**, Soil Scientist at the National Laboratory for Agriculture and the Environment, Ames IA, passed away in September of 2020. Dr. Cambardella was well known for her contributions on the role of particulate organic matter and soil aggregation on soil carbon and nutrient cycling.

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

The following scientists in NP 216 received prominent awards in 2020:

- **Dr. Dexter Watts** of the Soil Dynamics Research Laboratory, Auburn AL, was named a Fellow of the American Society of Agronomy in 2020.
- Scientists in the Genetics and Sustainable Agriculture Research Laboratory, Mississippi State, MS received the following awards in 2020: **Dr. Gary Feng** was elected a Fellow in the American Society of Agronomy; **Dr. Johnie N. Jenkins** was inducted into the Cotton Incorporated Hall of Fame; and **Dr. John Brooks** was invited to be the scientific advisor to the U.S. CODEX delegation to the International meeting in South Korea in December 2020.
- **Dr. Jay Jabro**, Research Soil Scientist with the Agricultural Systems Research Unit, Sidney MT, was named a Fellow of the American Society of Agronomy.
- **Dr. David Fleisher** of the Adaptive Cropping Systems Laboratory in Beltsville MD was also named an ASA Fellow in 2020.

The quality and impact of NP216 research was evidenced during FY2020 by the following:

- 180 refereed journal articles published;
- 14 new incoming agreements with collaborators;
- 1 new patent and 1 new invention disclosure submitted; and
- 91 students and postdocs training with ARS.

Selected Research Accomplishments for FY2020

Component 1. Building Agroecosystems for Intensive, Resilient Production via GxExM

Evidence of consistent and sustained profitability in precision agriculture cropping systems. Targeting management practices and inputs with precision agriculture has high potential to meet some of the grand challenges of sustainability in the coming century. The benefits include improving crop profitability and reducing environmental impacts, but its reputation for high cost limits its popularity. To better understand long-term effects of precision agriculture on crop profitability, ARS scientists in Columbia, MO, Long-Term Agroecosystem Research (LTAR) network site monitored a 90-acre field in central Missouri for over a decade under conventional management (1993–2003) and then for another decade under a precision agriculture system (2004–2014). Conventional management was a corn-soybean rotation, annual tillage, and uniform fertilizer and herbicide inputs. Key aspects of the precision system were no-tillage, cover crops, winter wheat instead of corn on areas with shallow topsoil and low corn profitability, and variable-rate fertilizer (nitrogen, phosphorus, potassium, and lime) applications. Results indicated that precision agriculture sustained profits in 97 percent of the field without subsidies for cover crops or payments for enhanced environmental protection. In a separate study, ARS scientists in Pendleton, OR, applied a specialized mathematical model to multiple years of yield map data from a dryland field in South Dakota (corn-soybean rotation) and an irrigated field in Georgia (corn, soybean, and peanut). In both cropping systems, this analysis method effectively revealed patterns of productive and unproductive parts of the field. This information can be used to target more efficient crop management techniques, and these results help growers gain confidence in the economic success of precision agriculture management and conservation practices.

Long-term data show crop diversity improves corn yields and enhances drought resilience. ARS researchers in Akron, CO; Lincoln, NE; Brookings, SD; and Beltsville, MD, in collaboration with scientists from universities across North America, compiled 347 seasons of data from 11 long-term experiments that spanned the continental precipitation gradient. Researchers found that more diverse crop rotations increase corn grain yield across all growing conditions by an average of 28 percent and that during drought years, corn yield losses were reduced from 14 to 90 percent. Crop rotation diversification is a risk-reduction strategy for producers under increasingly stressful weather conditions.

A framework for redistributing manure to meet regional production, economic, and environmental goals. Managing manure is one of the most difficult challenges of modern agriculture because excess manure can negatively affect water quality for human and environmental health. ARS scientists in Las Cruces, NM, and Tifton, GA, led a collaboration across 10 sites in the ARS Long-Term Agroecosystem Research (LTAR) network to classify 3,109 counties as “sources” of manure nitrogen and phosphorus from confined livestock production, or “sinks” that can use these nutrients to improve crop or hay production. The resulting four “manuresheds” represent various regional combinations of beef, dairy, poultry, and swine industries, and differ in the transport distances needed to productively use manure, from an average of 90 miles for a cattle-dominated system to 200 miles for a poultry-dominated system. Diverse stakeholders, including crop and livestock farmers, university extension staff, developers of manure-treatment technologies, and policymakers, can use the manureshed concept to develop strategies for recycling manure and transforming it from a liability to a valuable resource.

An inexpensive portable high throughput phenotyping (HTP) system for rapid crop assessment and precision management. Phenotyping is the process of collecting data about an organism's physical characteristics, which is useful for research in breeding better crop species or assessing plant response to stresses like drought and heat. Manually collecting this data is very time-consuming and requires a lot of labor, so scientists are working on ways to increase throughput by automating these measurements. An ARS researcher from Maricopa, AZ, developed and tested a low-cost wireless HTP system powered by a solar rechargeable battery. This system measures vegetation index, canopy temperature, and height from a multispectral camera, an infrared (IR) thermometer, and mini LiDAR sensors, respectively. This portable system can be mounted to unmanned aerial or terrestrial vehicles (drones) for use in fields or to indoor platforms for use in greenhouses or vertical farms. Because it is wireless, the data can be easily monitored from a smartphone or computer. The HTP system enabled automated irrigation control in a plant growth chamber based on soil water condition and automated collection of phenotypic data for months. This innovative data collection system has the potential to be adapted for use in commercial precision agriculture.

Perennial crops improve crop, livestock, and timber production. ARS researchers in Mandan, ND, teamed up with scientists in 9 countries to show that: 1) a change from annual to perennial crops over 20 years led to an average 20 percent increase in carbon in the top 12 inches of soil and a 10 percent increase in the top 40 inches; and 2) woody crops were most effective at increasing soil carbon. ARS researchers in Ames, IA , along with university collaborators, showed that widely-spaced oak and pecan trees near Fayetteville, AR, removed and stored in their above-ground biomass 0.75 and 0.2 Mg carbon per hectare per year, respectively, while enabling simultaneous livestock and timber production. This information is useful to producers who wish to combine agricultural production with environmental benefits of carbon removal from the atmosphere, and to people who are developing carbon offset markets that enable farmers to receive additional payments for this environmental service.

Pelletizing makes manure easier to transport from livestock facilities to fields. ARS researchers in Mississippi State, MS, evaluated the effects of using pelleted manure as a source of fertilizer nutrients and organic matter in corn, soybean, and cotton fields over 4 years. Grain and lint yields were comparable between pelleted manure and inorganic fertilizer nitrogen at equivalent nitrogen rates, while pelleted manure reduced nitrate percolation below the root zone. The practice of applying pelleted manure reduces the need for inorganic fertilizers and enables growers to maximize the return on their nutrient management practices while minimizing adverse impact on water quality.

Managing brush encroachment in desert grasslands. Arid grassland is degraded when woody plants crowd out grasses, resulting in intensified erosion. ARS scientists in Las Cruces, NM, established a collaborative long-term distributed experiment to measure the conservation effects of brush management in 45 treatment areas across southern New Mexico. Analysis of data from 5 to 10 years of vegetation monitoring indicates that grass restoration is favored at higher elevations and on specific ecological sites, whereas shrub reinvasion after treatment is more likely in soils with higher clay content and when shrub cover was initially high. This study will help land managers improve the success rate of grassland restoration efforts by predicting the effects of brush management on conservation and forage production outcomes.

Winter flooding of rice fields improves soil biology and waterfowl habitat but increases carbon footprint. ARS researchers at Jonesboro, AR, and Mississippi State, MS, evaluated trade-offs associated with a flooded winter fallow management option that is recommended by some conservation planners to provide waterfowl habitat. Winter flooding is beneficial for soil health as measured by soil biological activity, microbial groups, and plant nutrients, apparently due to fecal deposition by waterfowl as they frequent the flooded fields. However, methane gas emissions are higher during flooded than non-flooded fallow and can equal as much as 20–30 percent of those produced during the rice growing season. ARS researchers also found that methane can be reduced by up to half during the growing season, relative to conventional practices, when rice farmers use intermittent flooding, a water-conserving irrigation practice. These results show that methane emissions created by winter flooding can be offset by careful irrigation management during the rice growing season while protecting grain yield and groundwater resources. This information provides guidance to rice farmers who wish to manage their cropping system for profitability and environmental sustainability.

Evidence grows that reducing tillage intensity and planting cover crops improves soil health. Improving soil health builds the capacity of the soil to function as a vital, living ecosystem that sustains plants and animals, but it is a challenge to adequately measure the improvement that management practices have on soil health. ARS scientists in Ames, IA, and Columbia, MO, conducted a meta-analysis of 302 published studies throughout the United States to assess the effects of chisel plowing (CP), no-tillage (NT), and perennial cropping systems (PER) relative to moldboard plow (MP) on seven soil health indicators: soil organic carbon, microbial biomass carbon, microbial biomass nitrogen, soil respiration, active carbon, beta-glucosidase activity, and soil protein within 4 soil depth increments. Overall, reducing tillage by converting from MP to CP improved topsoil organic carbon, microbial biomass carbon, and respiration, whereas converting from MP to NT significantly increased all seven soil health indicators in the topsoil. Below the topsoil, NT resulted in greater microbial biomass, microbial carbon, respiration and beta-glucosidase activity relative to MP. Based on this analysis, reducing tillage intensity, planting cover crops, and/or minimizing crop residue removal within annual cropping systems can significantly improve soil biological health in the United States. Soil biological indicators are sensitive to management practices, confirming their utility in soil health assessment. Scientists can use this analysis to choose soil health measurements in their experiments that test the sustainability of different agricultural practices, and farmers will have added confidence that recommended practices improve soil health in a measurable way.

Powerful tools and techniques for monitoring rangeland production systems improve management and lower production costs. Standardized approaches for monitoring rangelands are needed to allow land managers and public land agencies to collect and share data that address numerous rangeland management and policy needs. ARS scientists in Las Cruces, NM, led the expansion of the rangeland monitoring program that directly supports the Bureau of Land Management (BLM) and Natural Resources Conservation Service (NRCS) national inventory and monitoring programs and the interagency National Wind Erosion Research Network. The Monitoring Manual for Grassland, Shrubland, and Savanna Ecosystems was published online, and physical copies were distributed to field staff. Statistical analysis tools and datasets were used by BLM and NRCS to produce reports and make management decisions regarding wildlife habitat suitability, evaluate conservation practice effectiveness, and improve grazing management systems across the continent's rangelands.

Removal of corn residue in semiarid irrigated systems reduces water use efficiency. Removing residue from corn fields for biofuel production offers an opportunity to increase farmer profits, but there are potential tradeoffs for water availability and crop performance. A multi-year collaboration between ARS researchers in Akron, CO, and scientists from Colorado State University compared the effects of two tillage practices (no-till and conventional), and two corn residue management practices (harvested and retention) on grain yields, water infiltration, evaporation, and soil quality. Corn grain yields increased and evaporative water losses were reduced with residue retention, especially under no-till. Water infiltration into the soil was higher with residue retention, resulting in higher water content in the soil at planting. The study suggests that high rates of crop residue removal under limited irrigation can negatively affect water conservation and yields, and that tradeoffs surrounding residue export need to be considered. These results will help irrigated corn growers in the region make better residue management decisions.

Component 2. Increasing Efficiencies for Agroecosystem Sustainability

Making Southwestern agricultural systems more resilient to weather variations. Weather-related challenges in U.S. southwestern communities and ecosystems include crop loss, extreme drought, variability in rangeland production, and wildfire. As members of the USDA Southwest Climate Hub (SW Climate Hub), ARS scientists in Las Cruces, NM, developed an online dust mitigation handbook with the Natural Resources Conservation Service (NRCS) and contributed to the AfterFire toolkit, an online post-fire resource for water managers. They also hosted an urban tree adaption workshop, expanded Grass-Cast (a forage production forecasting tool) to New Mexico and Arizona, conducted a survey of cattle producers to understand vulnerabilities to climate change and adaptation options, and co-launched the Drought Learning Network with climate scientists and land managers. These activities will assist farmers, ranchers, foresters, and other land managers in developing and implementing strategies to adapt to the impacts of extreme weather.

Mapping wheat grain protein concentration on-combine. Protein concentrations affect wheat quality and price, but the ability to map concentrations during harvest is unrealistic based on the high cost (more than $20,000) of commercially available spectrometers. ARS scientists in Pendleton, OR, adapted a moderately-priced reflectance spectrometer (less than $5,500) for use on a combine to measure and map the protein concentration of wheat during harvest. When calibrated, this instrument produced a protein map that was comparable to a map derived from a more expensive instrument. Having a less costly instrument for mapping protein across fields will enable more farmers to implement precision nitrogen management and to segregate and blend grain to achieve the desired quality.

Biosensor enables farmers to more confidently use seed meal as a soil amendment. Seed meal produced from canola and mustard can reduce pathogen pressure and suppress the germination of weeds by releasing glucosinolates (GCSs) and isothiocyantes (ITCs) into the soil. However, the widespread use of canola and mustard-based seed meal is hampered because these compounds can also suppress the germination of crop plants. Scientists in Corvallis, OR, developed a bacterial biosensor that detects biologically relevant concentrations of GCSs and ITCs in soil at much lower cost compared with advanced instrument methods. This technology is being developed into a method that can rapidly screen soils for the presence of ITCs, allowing growers to determine when it is safe to replant fields after the application of seed meals without suppressing crop germination.

Cover crops and compost increase soil health in long-term vegetable rotations. Soil organic matter often declines in tillage-intensive vegetable production systems, which can reduce soil health and productivity. Farmers working to improve soil management strategies need long-term information on how organic matter inputs from compost and cover crops affect soil organic matter levels. ARS researchers in Salinas, CA, and Beltsville, MD, evaluated changes over 8 years in soil organic matter in several vegetable rotations in the Salinas Valley that differed in the amount of organic matter input from winter cover crops and yard-waste compost. Although compost and cover crops both increased soil organic matter levels, frequent cover cropping had a greater impact on the type of organic matter that is more closely linked to increased crop yields and nutrient cycling. This information is useful to vegetable producers who seek to improve the profitability of their cropping systems through improved soil health.

Component 3. Reaching Agroecosystem Potential

High-quality forage can be produced from cover crops in place of summer fallow. Summer fallow degrades soil quality and is a non-sustainable cropping practice. Planting cover crops in place of fallow helps improve soil quality and can also provide a source of high-quality forage. ARS researchers in Sidney, MT, planted a 10-species crop mix (buckwheat, cowpea, flax, lentil, millet, mustard, pea, radish, sorghum, and turnip) in place of fallow in 2-year durum wheat rotations from 2014 to 2019. When harvested in early summer, this mixture produced prime quality forage at an average of 1.5 tons per acre. After forage harvest, regrowth of cover crops terminated by killing frost averaged 2.9 tons per acre of unharvested standing cover. Given the growing interest among producers in incorporating a diverse cover crop mix into their dryland cropping system to improve soil biological function, these results provide information about how a cover crop might also provide an immediate economic return when used as a forage.

Reducing our carbon footprint with renewable fuels grown on marginal land. ARS researchers in University Park, PA, showed that ethanol could be produced from barley with a carbon footprint less than half that of gasoline, allowing it to meet the advanced fuel standard of the U.S. Environmental Protection Agency. ARS scientists in Mandan, ND, along with scientists at Michigan Tech and the U.S. Department of Transportation, demonstrated that growing oilseeds in place of fallow in non-irrigated areas of the Great Plains reduces greenhouse gas (GHG) emissions, increases soil carbon, and could boost regional farmer incomes from $127 million to $152 million per year through jet fuel production. ARS scientists in Lincoln, NE, and Fort Collins, CO, determined that, compared to GHG-neutral continuous corn under conservation management, long-term (16 years) switchgrass systems mitigate GHG emissions during feedstock production by capturing more carbon in soil and mitigating nitrous oxide loss. ARS researchers in Temple, TX, identified genetic information in switchgrass that enables it to adapt to different growing conditions across a regional gradient from Texas to South Dakota. This research provides farmers with information about how to diversify income through emerging renewable fuel markets and provides policy makers with data needed to create programs to support renewable fuel production.

Improved methods to provide fertilizer recommendations and predict the effects of soil conservation practices on soil erosion. ARS scientists in Columbia, MO, along with scientists at 8 Midwest universities, evaluated 31 publicly available tools used in 49 field experiments to determine nitrogen fertilizer recommendations for corn. They found that yield-goal based tools recommended more nitrogen than necessary and that the tools using soil nitrate tests or measurements of leaf color came closest to the economically optimal nitrogen rate. ARS researchers in Tifton, GA, demonstrated the importance of using variable-rate simulated rainfall tests rather than the more common constant-rate simulation to measure soil erosion and nutrient loss under different tillage practices. Typical rainfall events were reflected more accurately when rainfall rate was varied during the simulation, while the advantage of no-till practice compared with conventional tillage was found to be diminished during high-intensity rainfall. This analysis of scientific methods is useful to scientists who want to improve the accuracy of their models as well as to land managers who want to improve their nitrogen management and soil conservation practices.