Welcome

USDA ARS National Program 216

Agricultural System Competitiveness & Sustainability

2013-2017 Retrospective Review Panel Discussion

April 16, 2018

Photo credit: Edwin Remsberg and USDA-SARE
11:00 – 11:30: Introductions and Background
   • Introductions of on-site and remote attendees
   • Today’s Approach
   • ARS 5-Year Research Cycle
   • Overview of NP216 Action Plan Components

11:30 – 12:00: Component 1 Review
   • ENHANCING THE YIELDS OF FOOD, FEED, FIBER, AND FEEDSTOCK PRODUCTION SYSTEMS

12:00 – 12:15: (Lunch prep/break)

12:15 – 12:45: Component 2 Review
   • ENHANCING PRODUCTION SYSTEM ECONOMICS VIABILITY

12:45 – 1:15: Component 3 Review
   • PRODUCTION SYSTEM EFFECTS ON NATURAL RESOURCES

1:15 – 1:30: Break

1:30 – 2:00: Component 4 Review
   • INTEGRATION OF SUSTAINABILITY GOALS

2:00 – 2:30: Final Discussion with all Attendees / Participants

2:30 – 4:00: Panel Only Discussion and planning for Critique development and delivery
1. Examples of accomplishments for each Component will be provided and summarized

2. A time for questions and discussion will follow each Component overview

3. The examples and conversations are designed to help the panel members review the success or deficiencies of the overall national program
National Programs in ARS are Mission Driven

- Keep Producers In Business
- Enhance Natural Resources Base
- Problem-solving Science
Provide farmers with management practices, decision aides, and information needed to “move farming systems along a trajectory toward greater sustainability on each of the four goals”:

1. Satisfy human, food, feed and fiber needs, and contribute to biofuel needs
2. Sustain the economic viability of agriculture
3. Enhance environmental quality and the resource base
4. Enhance the quality of life for farmers, farm workers, and society as a whole.
2013-2017 Action Plan
Components

• Component 1. Enhancing the yields of food, feed, fiber, & feedstock production systems
• Component 2. Enhancing production system economic viability
• Component 3. Production system effects on natural resources
• Component 4. Integration of sustainability goals
• Component 5. NEW: Closing the yield gap through:
  Genetics × Environment × Management
  \((G \times E \times M)\)
Vision: Help producers develop **integrated solutions** that solve their problems related to **productivity**, **profitability**, and **natural resource** stewardship.

C1. Enhancing the *yields* of food, feed, fiber, & feedstock production systems

C2. Enhancing production system *economic* viability

C3. Production system effects on natural resources

C4. Integration of sustainability goals: databases, models, tools, integration

C5: Closing the yield gap through interactions of genetics x environment x management (G x E x M) This component is being developed as a direction for new projects moving into NP216 from other ARS National Programs. GxExM will become a focus for NP216 during the five year cycle of research starting 2017.
Foci:

• To understand underlying agroecological principles for development of technologies

• To develop production strategies to produce the food, feed, fiber, and feedstock needed by society
Problem 1A:

Crop Production Systems

Crop production in most regions is dominated by one, or at most a few crops, with additional minor crops grown to meet market demands.

Knowledge and technology are needed for improved and diversified agronomic crop production systems to increase yield, reduce input costs, break weed and disease cycles, reduce economic and environmental risk, and distribute labor and equipment use over the cropping cycle.
Diverse agricultural systems are more complex, but more productive and stable

- To improve the resilience of agricultural systems, ARS scientists in Mandan, North Dakota examined the role of biodiversity in the management of agricultural systems.
- These complex systems require more management but can be more resilient than conventional systems.

**FINDINGS AND IMPACT:**
- Use of complex, adaptable cropping systems (Dynamic) increased spring wheat yield by 10-20%.
- Increasing system complexity by adding livestock decreased overwintering costs by up to 32%.

Improving Weed Control and Soil Conservation in Cotton Fields

- Benefits of conservation systems are numerous; Conservation tillage, after being widely adopted in the past few decades (Fig. 1), however, is now threatened by the development of herbicide-resistant weeds. Currently, there are 153 herbicide resistant weeds in the U.S.

- ARS scientists evaluated integrating high residue cover crops, crop rotation, alternative row spacings, and conventional, glyphosate and glufosinate-based cotton production systems.

**FINDINGS AND IMPACT:**

High residue cover crops are increasingly being incorporated into integrated pest management recommendations for their weed suppressive characteristics.

Cereal rye as cover crops grown before corn can increase incidence of corn seedling root diseases, but timing is critical

- Cereal rye cover crops in corn-soybean rotations can significantly reduce erosion, decrease losses of N and P, and increase soil organic matter.
- However, corn yields following cereal rye cover crops have been reduced during some years/some fields.
- One hypothesis is that cereal rye may be acting as a host for corn pathogens.

**FINDINGS AND IMPACT:**

- Discovery that as the interval between rye termination and corn planting increased, the amount of radicle root rot and incidence of *Pythium* on the radicle decreased.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Time Interval (d)</th>
<th>Radicle root rot incidence (%)</th>
<th><em>Pythium</em> incidence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No rye, control</td>
<td>No rye</td>
<td>58.3</td>
<td>0.0</td>
</tr>
<tr>
<td>Rye, 25 DBP</td>
<td>25</td>
<td>75.0</td>
<td>8.3</td>
</tr>
<tr>
<td>Rye, 14 DBP</td>
<td>14</td>
<td>72.2</td>
<td>22.2</td>
</tr>
<tr>
<td>Rye, 10 DBP</td>
<td>10</td>
<td>83.3</td>
<td>22.2</td>
</tr>
<tr>
<td>Rye, 3 DBP</td>
<td>3</td>
<td>91.7</td>
<td>61.1</td>
</tr>
<tr>
<td>Rye, 1 DAP</td>
<td>-1</td>
<td>100.0</td>
<td>75.0</td>
</tr>
</tbody>
</table>

Problem 1B:

Integrated Crop-Livestock Systems

Incorporation of livestock and poultry into crop production systems uses forage and grain to produce high protein products (e.g. meat, eggs, dairy)...

Knowledge and technology for improved integrated crop–livestock production systems are needed
Sustainability of integrated crop-livestock systems

- ARS and collaborators from France, Brazil, Uruguay, Argentina, and Ohio State University provided a synthesis of integrated crop-livestock systems as an option for sustainable intensification of agriculture

**FINDINGS AND IMPACT:**

- These integrated systems provide better regulation of biogeochemical cycles and decreased effects on the air and water systems

- They also favor diverse habitats and trophic networks and provide greater flexibility for the whole system to cope with potential socio-economic and climate change induced hazards and crises.

Integrated crop-livestock systems maintain soil quality

Information documenting the long-term impact of integrated crop-livestock systems on soil quality is lacking.

Nine years of detailed soil measurements found that:

**FINDINGS AND IMPACT:**

The findings are used to reassure farmers in the northern Great Plains that they can graze crop residue without negatively impacting the soil resource.

Problem 1C:

Organic Production Systems

Certified organic production represents a growing component within agriculture.

Knowledge and technology for providing nutrients, controlling weeds and other pests, and increasing yields are needed for improved, sustainable organic production systems.
Water quality in organic grain cropping and pasture systems (2013-2015)

Evaluated water quality in organic vs. conventional [drainage systems]

**FINDINGS AND IMPACT:**

- Nitrate N loss to subsurface drainage from 2013-2015 for organic C-S-O/A-A rotation was 53% lower than for the conventional C-S rotation.

- Subsurface drainage water nitrate N concentration still exceeded the 10 ppm drinking water standard 76% of the time for conventional C-S but only 26% of the time for the organic C-S-O/A-A rotation.

**Nitrate-N Load (lb N/ac) in Drainage Water**

<table>
<thead>
<tr>
<th>Rotation</th>
<th>2013*</th>
<th>2014*</th>
<th>2015*</th>
<th>Σ 2013-2015*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic C-S-O/A-A</td>
<td>21.2</td>
<td>13.0</td>
<td>8.9</td>
<td>43.1</td>
</tr>
<tr>
<td>Conventional C-S</td>
<td>44.7</td>
<td>32.4</td>
<td>13.9</td>
<td>91.0</td>
</tr>
<tr>
<td>Organic Pasture</td>
<td>8.5</td>
<td>1.1</td>
<td>1.0</td>
<td>10.6</td>
</tr>
</tbody>
</table>

*Quantities significantly different among rotations

Genetic control of hairy vetch flowering time decoded for potentially improving varieties for use in organic farming.

- Winter cover crops reduce soil erosion, prevent loss of nutrients during the winter, and improve soil organic matter and soil health.

- For no-till organic cropping systems, onset of flowering indicates earliest time cover crops can be mechanically terminated without herbicides or tillage.

**FINDINGS AND IMPACT:**

- ARS Scientists in Beltsville MD identified five key flowering genes associated with initiation or inhibition of flowering that are regulated during transition from vegetative to flowering growth stages.

- Earlier-flowering cover crops permit earlier spring planting of the next crop.

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Component 1 Review

Questions & Discussion
Foci:

To understand the economic factors affecting production system profitability

To develop appropriate strategies for profitable food, feed, fiber, and feedstock production
Problem 2A:

Farm-Scale Economics

Volatile commodity prices and increasing input costs represent economic challenges for producers.

Understanding the factors affecting farm-scale profitability and developing strategies for optimizing producer income are needed.
System for Segregating Hard Red Wheat by Protein Content
Rewards Growers

• Grain segregation in the harvesting process may have the ability to capture high protein grain within fields.

FINDINGS AND IMPACT:

• Segregating grain can increase net returns to over $9.00/acre compared to bulking (depending on year)

Net returns from segregating dark northern spring wheat by protein concentration during harvest.
Assessing Environmental Stress in Wheat to Improve Precision Agriculture

- Multi-sensor system for measuring grain yield, grain protein, and straw yield on the combine developed

**FINDINGS AND IMPACT:**

- Producers can identify specific regions within fields where grain yield was impacted by early- or late-season stress

**INPUTS**
- Yield monitor
- Protein sensor
- Crop height (lidar)

**OUTPUTS**
- Harvest Index
- Straw to grain ratio
- and more

Map of four stress categories.

Scatter plot between grain- & straw-yield identifies four stress categories: early in season (green), late in season (blue), both (red), or little stress (black) [See Coapland et al. 1996]

Long-term evaluation of cover crop biomass production and nitrogen accumulation in high-input, tillage-intensive production systems

- Long-term research examined cover crop performance across years during variable winter climatic conditions
- Cover crop biomass production and nitrogen accumulation were evaluated

**FINDINGS AND IMPACT:**

- Rye and legume-rye produced 25% more cover crop biomass than mustard and the legume-rye accumulated 35% more nitrogen
- Developed ecologically-based soil and pest management strategies that enhance soil health, nutrient cycling, and profitability

Terrain-based variable nitrogen management found unprofitable in dryland wheat production systems

Investigated in 8 farm fields in northern Montana

Basis:
- conventional N recommendations,
- terrain-based zones, and
- average Portland prices for hard red spring wheat

FINDINGS AND IMPACT:
Variable N management was not more profitable than uniform N management; average net returns were up to $11/ac less

Would have been profitable in:
- years with large price spreads in fields, and
- growing seasons with above average yields

Problem 2B: Macro-economics

Agricultural production represents a significant component of the United States economy and makes a positive contribution to the country’s balance of trade.

Strategies for optimizing the contribution of agricultural production to the United States economy are needed.
Crop Residue Supply for Bioenergy

- Transportation costs commonly result in residue harvest being concentrated near a biorefinery, concentrating environmental impacts near the facility as well

**FINDINGS AND IMPACT:**

- Farmers could begin to profitably deliver corn stover at prices *above $53 per ton*

- Findings indicate that most profitable tillage and crop rotation practices shift in response to increasing biomass price with producers shifting from a corn-soybean rotation toward continuous corn

Cropland Rental Tool (CROPRENT) is a excel-based decision tool developed for comparing different cropland lease agreements, including flexible cash rents, for up to five crops and/or management systems.

**FINDINGS AND IMPACT:** Flexible cash rents allows rents to vary from year-to-year based on changes in price, yield, or revenue, allowing tenants and landowners to share in the risk associated with volatile commodity prices and uncertain yields.

CROPRENT is downloadable for free, with the accompanying User Manual, from: [http://www.cottoninc.com/fiber/AgriculturalDisciplines/AgriculturalEconomics/Cotton-Farming-Decision-Aids](http://www.cottoninc.com/fiber/AgriculturalDisciplines/AgriculturalEconomics/Cotton-Farming-Decision-Aids)
Component 2 Review

Questions & Discussion
NP216. Agricultural System Competitiveness & Sustainability

C3. Production system effects on natural resources

Foci:

To understand the physical, chemical, and biological processes in production systems, and

To develop strategies for meeting air, water, and soil quality expectations of society
Problem 3A:

Air Quality

Agricultural production systems interact with the atmosphere affecting air quality.

Management practices that maintain or improve air quality are needed.
Grazing sheep during fallow reduces greenhouse gas emissions while maintaining crop yields

• Investigated managed sheep grazing in rotations with different crop rotations

**FINDINGS AND IMPACT:**

• Sheep grazing increased soil organic C and total N in spring wheat-pea/barley-fallow rotation compared with tillage and herbicide application for weed control

• Sheep grazing had no effect on crop yield compared with tillage and herbicide application

Long Term Agricultural Research (LTAR) Network rangeland wind erosion research leads to improved models and calibrations for more effective management

- Rangeland wind erosion causes: losses of productivity, highway fatalities, health problems & abrasive damage

- ARS coordinated research & modeling efforts for wind erosion at 9 LTAR network locations.

**FINDINGS AND IMPACT:**

- Outcomes will help develop new models to assess current land management, land use, and rangeland wind erosion, providing insights needed to reduce wind erosion problem.

Problem 3B:

Water Quality

Agricultural production systems affect surface and ground water resources

In many regions production is dependent on irrigation

Management practices that maintain water quality and optimize water use efficiency are needed
Oat and rye cover crops substantially reduce nitrate losses in drainage water

- ARS scientists in Ames, Iowa, showed that a winter cover crop reduced the concentration of nitrate in drainage water

**FINDINGS AND IMPACT:**

- Oats reduced nitrate concentrations by 26%
- Rye reduced nitrate concentrations by 46%

Stream and river water quality linked to land-use practices

- Assess how land use alters water quality of nearby streams and rivers for pollution monitoring and natural resource stewardship

- Tools needed to quantify how land use alters stream and river water quality over long time periods

- ARS scientists in Corvallis OR collected data over an 8-year period to define 56 land-use patterns of crops, forests and urban development that represented 99% of the area in the Willamette River Basin of western Oregon.

**FINDINGS AND IMPACT:**

- When used with SWAT, data of different land-use patterns can now be used to project the potential environmental consequences of land use patterns changing in response to market forces, policies and climate.

Efficient water use in corn production

• Due to uncertainty in amount/timing of precipitation during cropping season, producers in the Mississippi Delta depend heavily on supplemental irrigation

• ARS scientists in Stoneville, MS evaluated at which growth stages of corn, irrigation water can be reduced—without affecting yield

**FINDINGS AND IMPACT:**

• Reducing water to 75% after milk stage did not affect yield. *With additional tests, this information can help producers save money by reducing irrigation water at those growth stages in corn*

Problem 3C:

Soil Quality

Agricultural production systems affect soil physical, chemical, and biological properties.

Management practices that maintain or improve soil quality are needed.
Molecular Biology Tools for Use in Assessment of Soil Health and Microbiomes

• ARS scientists in Beltsville, MD developed a suite of affordable molecular biology tools for use in soil health assessment
  • Bacterial / fungal community structure
  • Nematode abundance / pathogen potential
  • Functional gene abundance
  • Updated protocols for estimates of biologically active soil DNA and RNA
• Found significant differences in sizes and diversity of groups of soil organisms among long term cropping systems

FINDINGS AND IMPACT:
• Results aid farmers, extension agents and researchers exploring soil health and needing to assess sustainability of agroecosystems.

Long-term reduced till with continuous cropping reduces soil carbon and nitrogen losses

Investigated C and N losses associated with conventional and no till practices in wheat and impacts of residue vs. fertilizers

**FINDINGS AND IMPACT:**

- Continuous N fertilization reduced soil pH, Ca, and Mg, but greater crop residue returned to the soil increased P, K, Na, Zn, and CEC in reduced till continuous spring wheat compared to conventional till spring wheat-fallow.

- No-till continuous spring wheat reduced soil C and N losses by 10% compared with 30-35% losses with conventional till spring wheat-fallow after 30 years of converting grassland to cropland.

- Mean annualized spring wheat yield was 23-30% lower in conventional till spring wheat-fallow than reduced till continuous spring wheat.

Problem 3D:

Environmental Quality

Changing management practices to reduce negative effects of production practices on the environment may have an unintended impact of shifting the negative outcomes to another part of the environment.

Active research is needed that jointly addresses both land management and its effects on natural resources to ensure that agricultural production practices maintain or improve environmental quality.
Organic cropping provides ecosystems services that rival no-till cropping

Soil Organic Carbon (to a depth of 1m) in corn–rye–soybean–wheat/legume rotations was 11% greater in a manure-based organic, 3 year trial (a) compared to a no till system (b) after 11 years.

**FINDINGS AND IMPACT:**

<table>
<thead>
<tr>
<th>System</th>
<th>Potentially mineralizable N</th>
<th>Frequency of manure application</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>229 b</td>
<td>NA</td>
</tr>
<tr>
<td>NT</td>
<td>241 b</td>
<td>NA</td>
</tr>
<tr>
<td>Org2</td>
<td>297 a</td>
<td>1 of 2 yrs</td>
</tr>
<tr>
<td>Org3</td>
<td>323 a</td>
<td>2 of 3 years</td>
</tr>
<tr>
<td>Org6</td>
<td>325 a</td>
<td>2 of 6 years</td>
</tr>
</tbody>
</table>

**Greenhouse gas emissions**

<table>
<thead>
<tr>
<th>System</th>
<th>ΔSoil C</th>
<th>N₂O</th>
<th>Energy</th>
<th>GWP</th>
</tr>
</thead>
<tbody>
<tr>
<td>No-Till</td>
<td>0 b</td>
<td>303 b</td>
<td>807</td>
<td>1110 b</td>
</tr>
<tr>
<td>Chisel Till</td>
<td>1080 a</td>
<td>406 ab</td>
<td>862</td>
<td>2348 a</td>
</tr>
<tr>
<td>Organic</td>
<td>-1953 c</td>
<td>737 a</td>
<td>344</td>
<td>-872 c</td>
</tr>
</tbody>
</table>

Agroforestry has potential to mitigate agricultural greenhouse gas emissions in the southeastern USA

Long term silvopasture experiments in North Carolina were initiated in 2007 by planting trees on marginal cropland. It has demonstrated a multi-disciplinary approach to conservation agriculture using a systems approach. Impacts on greenhouse gas emissions are notable.

FINDINGS AND IMPACT:

![Graph showing N₂O Flux](image-url)
Component 3 Review

Questions & Discussion
Vision: Help producers develop integrated solutions that solve their problems related to productivity, profitability, and natural resource stewardship.

**C4. Integration of sustainability goals: databases, models, tools, integration**

**Foci:**
- To overcome problems related to the synthesis of data for assessments of sustainability at the farm/regional/or larger scales
- To develop databases and analytical tools for processing datasets, and to use or develop statistical methods, assessment tools, and simulation models - to synthesize results that farmers, ranchers, and other producers can use in organizing their operations to enhance their sustainability.
Problem 4A:

Database Development

Agricultural production research is conducted at a large number of ARS locations, and at cooperating university and non-profit research organization

Comparison of results is often hampered by lack of access to data

Development of a database for storage and access is needed to integrate and validate research across locations, regions, and nationally.
Meta-data requirements for conservation agricultural systems research outlined

• No-till/conservation agricultural systems research has been studied for >50 years in countries around the world; however, few standards in methodology exist

• Scientists from Paraguay, Germany, Italy, and Brazil and ARS scientists at Raleigh, NC and Morris, MN outlined necessary standards of conservation / agroecosystems research.

**FINDINGS AND IMPACT:**

• Standards in research methodologies in no-tillage/conservation agricultural systems will improve abilities to compare results from different researchers/ countries

Sustainable Nutrients & Water Management Technology – for addressing groundwater decline in the Mississippi Delta

• Research on yield gaps in southeastern crops is challenging, given the high variability in soil types, volatile weather, and biotic and abiotic stresses during the growing season

FINDINGS AND IMPACT:
• Models were developed that are used in conjunction with collected data to estimate and predict water utilization strategies and use future weather predictions to estimate crop nutrient use

Problem 4B:

Synthesis and Modeling

Modern data collection methods are capable of generating very large datasets that are difficult to process for meaningful information.

Methods and tools are needed to better understand underlying processes and responses to modern production practices.

Tools include methods for processing, filtering, and incorporating these datasets into a common format, and statistical methods, assessment tools, and agronomic models to synthesize and compare results across locations.
Platform and mobile apps developed for collecting and sharing G × E × M data

- ARS scientists in Las Cruces New Mexico, with support from USAID, NRCS other scientists, developed a “Land-Potential Knowledge System” (LandPKS) App.

- Optimal seed selection & management requires knowledge of soil, topography & climate for the location where germplasm & management systems were tested - and where they will be used.

**FINDINGS AND IMPACT:**

- This App will help farmers in the US and globally sustainably intensify production systems.

Long-term field management database

- ARS researchers in University Park, PA developed a framework for recording land management, water quality and related data.

FINDINGS AND IMPACT:
- Database supports research to help farmers meet long-term production, land stewardship, and water quality goals.
- Expected to help develop options for management that improve water quality.

Geospatial databases and operational framework for predictive disease ecology

Vesicular stomatitis virus (VSV) [most common vesicular disease affecting livestock in the Americas] has expanded to ~250M acres between 2004 - 2016.

ARS scientists (Las Cruces), in collaboration with other ARS scientists and APHIS developed a spatially-resolved, iterative framework with human and machine learning to address this problem: a DATA CUBE.

**FINDINGS AND IMPACT:**
New insights were discovered about the effects of drought, surface water, soil, and vegetation properties on host-vector relationships that contribute to variability in the spread of disease. The harmonized, spatially- and temporally resolved data cube can be used for other research questions in the geographic region of the analysis.
Long Term Agroecosystem Research (LTAR) Network
Rangeland Wind Erosion Research and Model Calibration

• A coordinated multi-partner *National Wind Erosion Research Network*
• 7 LTAR sites, 2 ARS labs and 5 BLM field offices (9 sites are operational)
• Basic and applied research into wind erosion and dust emission processes

**FINDINGS AND IMPACT:**
• Developing wind erosion models to enhance national wind erosion monitoring and assessment programs
• Integrating data and models with BLM and NRCS rangeland monitoring programs

https://doi.org/10.1016/j.aeolia.2015.11.006
Component 4 Review

Questions & Discussion
Vision: Help producers develop integrated solutions that solve their problems related to productivity, profitability, and natural resource stewardship.

2. Enhancing production system economic viability

NP216. Agricultural System Competitiveness & Sustainability

1. Enhancing the yields of food, feed, fiber, & feedstock production systems

Soil health
Long term sustainability
Energy production
Cover crops

3. Production system effects on natural resources

PM10 emissions
Nutrient management
Soil carbon & nitrogen
Carbon balance
Sustain crop yields

Wind Erosion
Soil Erosion
Greenhouse gases
Model improvement

4. Integration of sustainability goals: databases, models, tools, integration

5: Closing the yield gap through interactions of genetics x environment x management (G x E x M) This component is being developed as a direction for new projects, moving into NP216 from other ARS National Programs. GxE will become a focus for NP216 during the five year cycle of research starting 2017.
2013-2017 NP216

1. Summary Conversation

2. Panel Only Conversations