# NLAE Stakeholder Meeting

March 27th 2018

Ames, IA.

National Laboratory for Agriculture and the Environment

# National Laboratory for Agriculture and the Environment

## Stakeholder Meeting

### March 27, 2018

8:00 Registration

Opening session

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| 8:30 | Welcome – Jerry Hatfield |
| 8:45 | Overview of ARS and Midwest Area – JL Willett |
| 9:00 | Long-term Agroecological Research (LTAR) - Tom Moorman |
| 9:15 | Soil, Water, and Air Research – Tom Sauer |
| 9:45 | Agroecological Management Research – Tom Moorman |

10:15-10:45 Break (poster viewing and interactions)

NLAE as a Problem-Solving Laboratory

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| 10:45 | Watershed Management Tools (ACPF) - Mark Tomer |
| 11:15 | Enhancing diets for swine and poultry – Brian Kerr |
| 11:45 | Discussion |

12:00-1:00 Lunch

Challenges Facing Agriculture- Working across scales and disciplines

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|---|---|
| 1:00 | Production problems- Matt Vickers |
| 1:30 | Conservation of soils – Clare Lindahl |
| 2:00 | Environmental Concerns – Jennifer Terry |
| 2:30 | Animal Systems for the Future - Chris Hostetler |

3:00-3:30 Break

3:30 Building Partnerships to Solve Problems

Tom Buman, Importance of Communicating to the Public and Transferring Results

Panel Discussion

4:15 Wrap-up – Jerry Hatfield

## *Preface*

The National Laboratory for Agriculture and the Environment was formed in 1989 as the National Soil Tilth Laboratory and renamed in 2009 to the current name. This name change was made to more accurately reflect our research mission of generating information which addresses critical problems in agriculture and watershed management leading to the development of innovative solutions which increase the efficiency of agriculture systems and reduce environmental risk. It has been almost 30 years since we began this research program and over the years we have changed our projects, expanded our partners, and have grown more mature, in both our science and our gray hair. However, in that time we have never strayed from the idea of conducting research that addresses a problem and transferring that information to provide answers to the wide range of stakeholders.

We have been holding these stakeholder meetings every two years for the purpose of acquainting you as a stakeholder with our current activities. This year, our intent is to showcase the problems we have been working on and the application of this information toward solving that problem. Throughout this report, you will see a variety of group projects and individual scientist's efforts as part of groups. These are provided to give you a glimpse of the breadth of projects we have underway.

One of the purposes of this stakeholder meeting is to provide you with an opportunity to learn about our research programs. The other valuable purpose, is for us to learn from you as to the challenges you see facing agriculture in the next decade and beyond. As a laboratory, we want to be looking to where our science can answer problems that are just emerging so we can be proactive rather than reactive. As all of you are aware, agriculture does face some challenges and we want our science to be able to provide answers to those questions before they become crises.

One part of this overview is our staff snapshots. These are brief and don't fully encompass all of the skills and impact our staff has had and continues to have. Our scientific staff has a national and international reputation for their accomplishments and this would not be possible without the efforts of our support staff in the field, laboratory, and administration. Personally, I can't express my thanks to everyone in NLAE for their dedication and efforts to make this the best laboratory in ARS.

We hope you enjoy this overview and your time of being with us. However, I know that many of you interact with us on a continual basis and we welcome that opportunity to share our results and our research program with you at any time. It is your feedback and counsel that has helped shape and challenge this laboratory over the past 30 years and we look forward to expanding and strengthening these partnerships.

Feel free to contact us any time at

Jerry.hatfield@ars.usda.gov

515-294-5723

## *Meet the Research Staff and their Accomplishments*

## Dr. Bradley Bearson

*Microbiologist*

**Research Team:** Bradley L. Bearson, Shawn M.D. Bearson, Kellie Winter, and Margaret Walker.

**Problem**: Non-typhoidal *Salmonella* is a leading cause of foodborne disease (estimated 1 million illnesses/year) and food-related deaths (~500 deaths/year) in the U.S. Food-producing animals are frequently asymptomatic carriers of *Salmonella* and consequently a reservoir for the foodborne pathogen. There are over 2,500 serovars or types of *Salmonella* and on-farm control is complicated due to serovar-specific immune responses that do not provide broad protection against a variety of *Salmonella* serovars to which an animal could be exposed.

**Objective 1**: Evaluate alternatives to antibiotics (butyric acid, resistant starch, inulin, etc.) for maintaining growth performance and reducing intestinal bacterial translocation and shedding in growing pigs.

**Objective 2**: Determine whether vaccination of swine with a *Salmonella* DIVA vaccine can prevent/reduce colonization and improve growth following transmission of *Salmonella* from actively shedding pigs.

**Approach**: Exposure of an animal to *Salmonella* induces an immune response with the production of antibodies that bind *Salmonella* lipopolysaccharide (LPS), an immunodominant and serovar-specific antigen. In the rational design and construction of the *Salmonella* vaccine, a genetic mutation was incorporated that reduces LPS production. Vaccination with the live, attenuated *Salmonella* vaccine does not induce antibodies against *Salmonella* LPS, thus allowing for the differentiation of infected from vaccinated animals (DIVA). The live, attenuated *Salmonella* DIVA vaccine permits animal vaccination without compromising *Salmonella* surveillance programs that utilize an assay to detect animal antibodies that bind to *Salmonella* LPS indicating a previous exposure to the pathogen. The *Salmonella* vaccine has been evaluated in swine and turkeys to reduce disease, colonization, and fecal shedding due to multiple *Salmonella* serovars. U.S. (15/108,725) and European (14877328.6) patent applications describing the design, construction, and evaluation of the *Salmonella* vaccine technology have been filled by the USDA.

**Application of technology and impact**: An exclusive license for commercialization of the *Salmonella* vaccine technology has been granted to a commercial partner. Currently the commercial partner is performing the necessary experiments and preparing documentation for licensing of a veterinary biologic through the USDA, APHIS, Center for Veterinary Biologics to allow production and distribution of the *Salmonella* vaccine for use in food-producing animals.

**Partners**: The *Salmonella* vaccine technology was designed and evaluated by scientists at the USDA, National Laboratory for Agriculture and the Environment and the USDA, National Animal Disease Center.

**Accomplishments**: Design, evaluation, and transfer of a Salmonella vaccine technology to a commercial partner.

**Extramural research projects**: Iowa Pork Producers Association - *Salmonella* DIVA vaccine for cross-protection against *Salmonella* serovar I 4,[5],12:i:- minimizing antibiotic usage and protecting swine and public health.

National Pork Board - Assessing the unintended effects that therapeutic antibiotic treatment has on multidrug-resistant *Salmonella* in swine: implications for swine health and food safety

**Collaborators and partners**: A collaboration between NLAE and multiple individuals at the National Animal Disease Center is ongoing for the investigation of interventions (including alternatives to antibiotics) against *Salmonella* and *Campylobacter* in food-producing animals to enhance animal production and improve food safety.

Shawn M.D. Bearson (USDA, ARS, National Animal Disease Center, Ames, IA), Brian W. Brunelle (formerly USDA, ARS, National Animal Disease Center, Ames, IA), Heather K. Allen (USDA, ARS, National Animal Disease Center, Ames, IA), Crystal L. Loving (USDA, ARS, National Animal Disease Center, Ames, IA), Matthew J. Sylte (USDA, ARS, National Animal Disease Center, Ames, IA), Torey Looft (USDA, ARS, National Animal Disease Center, Ames, IA)

## DR. CYNTHIA A. CAMBARDELLA

*Research Soil Scientist*

**Collaborators**: USDA-ARS: CEAP, LTAR, GraceNet, REAP

**Individual and Team Research at NLAE**

Dr. Cambardella's research program requires a creative approach that integrates agricultural and ecological principles at multiple scales in space and time, with the following objectives: 1) Quantify the dynamics of C and N cycling in agricultural and natural ecosystems; 2) Determine the spatial and temporal variation in soil properties and processes that affect soil health and water quality; and 3) Assess the impact of agricultural management practices (e.g. tillage, crop rotations) and natural ecosystem attributes (e.g. soil type, topography, plant communities) on the partitioning and flux of carbon and nutrients in the soil-plant-water system. This research provides quantitative information about ecological processes that control C and N cycling in the soil-plant-water system. Integrative information on C and N cycling and nutrient-use efficiency impacts our ability to quantify the risk of nitrate contamination of surface and groundwater and the design of prevention and mitigation strategies. All of these impact areas are major national concerns and priority areas within ARS long-term plans. Demonstrated progress toward a more complete, mechanistic understanding of the complex interactions and feedbacks that control C and nutrient cycling and retention will represent a significant advancement of science.

**Partnerships:**

- Iowa State University (ISU): (1) Evaluate impacts of cropping system diversity and input reduction on greenhouse gas mitigation, soil and water quality, and economic performance of Iowa grain systems. (2) Effect of cover crops, soil amendments and reduced tillage on carbon sequestration and soil health in an organic grain and vegetable systems. (3) Understanding soil organic matter change: root and soil interactions across agricultural landscapes.
- DOI-USGS: Soil carbon cycle science in tallgrass prairie ecosystems.
- USDA-NRCS: Meta-analysis of soil quality indicator variables for the Soil Management Assessment Framework (SMAF).
- University of Northern Iowa (UNI): Determining maximal sustainable production of biomass with mixture of prairie species.
- ISU, Purdue University, University of Illinois, University of Missouri, University of Minnesota, Agri-food Canada, International Plant Nutrition Institute (IPNI): Coordinated site network for studying the impacts of 4R management on crop production and nutrient loss.
- Arizona State University, Applied Ecological Services, Inc.: Evaluate landscape-scale impacts of Adaptive Multi-Paddock (AMP) grazing systems on soil carbon sequestration and ecosystem services.

**Problem 1**: Agricultural nitrate has contaminated surface and groundwater in the upper Midwest, but the controlling agronomic and hydrologic factors are poorly understood.

**Approach:** A potentially beneficial strategy for improving water quality is organically managed cropping systems with extended rotations that include small grains and forage legumes. Dr. Cambardella and coworkers quantified nitrate-N concentrations for a watershed in central Iowa and demonstrated that nitrate-N losses to tile drainage water are controlled more by precipitation patterns than by the timing of chemical application or soil conditions. Most of the nitrate-N was lost when crops were not present, emphasizing non-growing season N mineralization as a major contributing factor to N loss. In a more recent study, Dr. Cambardella quantified tile drainage water nitrate-N loss for an organic corn-soybean-oats/alfalfa/alfalfa rotation and a conventional corn-soybean rotation and found N loss was reduced 50% for the organic rotation compared to the conventional rotation, demonstrating the potential for organic grain cropping systems to reduce N loss to surface water.

**Application of information and impact:** The watershed-scale research helped define the pathways and timing of nitrate export from the Upper Mississippi Basin and the need to control losses of nitrate in tile drainage. The results have been adopted for the design of national watershed-scale research projects, such as the ARS/NRCS Conservation Effects Assessment Program (CEAP) and the ARS LTAR. Results of the organic study have been widely distributed through invited presentations at a OECD-sponsored conference in Long Beach CA, the First Organic Confluences Summit in Washington, D. C., two National Press Foundation workshops, an NRCS-sponsored webinar on environmental impacts of organic farming, and regional conferences, workshops, and field days.

**Partners**: Iowa State University

**Problem 2**: Accurate assessment of soil quality/health at the field and watershed scale is a critical first step to understanding the linkage between soil response to agricultural management practices and concomitant effects on ecosystem services.

**Approach**: Using systematic landscape sampling and terrain analysis, Dr. Cambardella and co-workers determined that soil quality/health was greater in a ridge-till watershed than in adjacent watersheds in the loess hills of southwest Iowa managed with conventional tillage. Terrain analysis identified that soil quality/health in erosion-prone areas of the landscape was specifically greater in the ridge-till watershed than in the conventional till. Soil quality/health indices were constructed using the Soil Management Assessment Framework (SMAF), a tool that was developed to assess impacts of soil management practices on soil function.

Application of information and impact: This research outlined the framework for SMAF and was the first to use SMAF to assess soil quality/health at the watershed scale. The SMAF, which provides site-specific interpretations for soil quality/health indicator results, was selected as the method to assess soil quality/health for the national ARS/NRCS Conservation Effects Assessment Program (CEAP).

**Partners**: USDA-NRCS

# DR. CHRISTIAN DOLD

*Postdoctoral Researcher*

**Research**

- Carbon and nitrogen cycling in agricultural fields, agroforestry systems, and natural ecosystems
- Quantification of water stress in crop production
- Soil-water-plant-atmosphere relationships
- Accomplishments and Impact

**Water stress:** Water limitations in summer and oversupply of water in spring can lead to the reduction of corn and soybean yield in Iowa. The quantification of water stress in plants (that is, yield or growth limiting water conditions in the soil) is therefore important to reduce possible yield losses. The measurement of leaf temperature in relation to the weather conditions (e.g. air temperature, relative humidity etc.) has proven to be a good estimator of plant water stress, because water stressed plants close their stomata which eventually increases leaf temperature. Leaf temperature can be measured with infrared thermometers, and with the help of local weather station data water stress is quantified. Measurements in corn and soybean showed an increase in water stress, when the amount of water in the soil decreased as well as excessively increased. Plants close their stomata under both soil water conditions, leaf temperature increases, and plants wilt. These estimations (and in combination with growth and yield data) allow for the evaluation of yield limiting conditions.

**Impact:** Using this method, we tested novel spraying agents from the private sector on corn, wheat, and soybean. These spraying agents have been proven to positively impact crops under water stress, yet, only under controlled conditions. The next step was the evaluation under field conditions. A field trial was designed, and plant growth, yield, and water stress was estimated. These results are important to develop a marketable spraying agent for the agriculture sector.

**Soil quality***:* The most common cropping system in Iowa is corn-soybean rotation with a short growing season from May-October and bare soil during winter and early spring. However, this continuous rotation system can lead to a reduction of soil carbon and nitrogen contents. For example, we estimated a reduction of organic carbon in the upper 6-inch soil layer of approximately 660 lb per acre per year from 2005 to 2016 in a corn-soybean rotation in Central Iowa. Soybean-years are most affected: the plants don’t provide enough biomass to the soil, while at the same time the corn residues from the previous year are mineralized.

**Impact***:* Soil carbon is an important estimator for soil quality. It is a proxy for soil organic matter, and has proven impact on the water storage capacity of soils. Besides, a reduction of soil organic matter is often accompanied with a decrease of nitrogen, which leads to an increase demand of mineral fertilizer or manure in crop production.

# DR. JERRY L. HATFIELD

*Laboratory Director and Supervisory Plant Physiologist*

Responsible for the management of the research program in NLAE. Personal research focuses on understanding the interactions among components in the soil-plant-atmosphere continuum using meteorological and remote sensing methods. Lead scientist on a project entitled "Utilization of the G x E x M Framework to Develop Climate Adaptation Strategies for Temperate Agricultural Systems."

## *Weather and Climate Impacts on Agricultural Productivity*

**Investigator**: Jerry L. Hatfield

**Project Team**: Wolfgang Oesterreich, Michelle Cryder, Laura Hansen, Albert Swalla, Jacob Wright, Mariah Schemmel, Kaitlyn Herold, Catherine Thom, Kyle Gansen

**Post-docs**: Erica Kistner, Christian Dold, Kenneth Wacha

**Problem**: Variation in production among years in agricultural crops is a function of the weather within the growing season. What is not understood is the potential magnitude of these impacts across the United States given the trends in climate that are occurring. There have been a number of questions addressed around this problem to quantify the response of crops to changes in weather and climate.

**Approach**: The approach that was developed to quantify these impacts in based on the calculations of yield gaps. Crop yield data are available from the National Agriculture Statistics Service at the county level for agricultural crops and have been assembled for corn, soybean, and wheat across the United States. The data are analyzed to compute yield gaps as a function of the difference between the attainable yield and actual yield with the attainable yield define as the upper frontier of the observed yields for each year. These yield gaps have been related to weather during the growing season and it was found for corn and soybean, July maximum. August minimum and July-August total precipitation were related to these yield gaps. For wheat, the primary meteorological variable was the precipitation amounts during the grain-filling period.

Controlled environment studies have been conducted on corn and wheat on the impact of increased temperatures on growth and productivity. For corn, we used three different hybrids grown under normal Ames, Iowa temperatures and normal plus 4C (7F) with no soil water limitations. For wheat, we used normal Salina, Kansas temperatures and three soil water regimes of 1.25 field capacity, Field capacity, and 0.75 field capacity to create a range of soil water availability to the crop.

**Observations**: The yield gap analysis revealed that exposure to maximum and minimum temperatures above the temperature range for the crop caused a reduction in grain yield due to an increase in the rate of plant development. The controlled environment studies coupled with field observations showed the impact of minimum temperatures on the rate of grain-filling. Available soil water remains a primary factor affecting yield across the United States.

**Solving the Problem**: We can't change the weather but we can reduce the impact of weather variation. The trends in climate reveal that summer rainfall will become more variable and decrease which has the potential to increase variation in yield among years. To counteract this effect, soil management practices have to increase the water storage in the soil by increasing the infiltration rate and reducing the soil water evaporation amounts. This can be done by how we manage tillage and crop residue to enhance our soils. Overcoming climate impacts to increase resilience to the increased variation requires we understand how genetics, environment, and management interact. We can increase yield stability and total yield in our cropping systems through a combination of improved management to allow the genetic resources to be optimized.

**Partners:**

NASA-Jet Propulsion Laboratory (Karen Yuen, Darren Drewy) Utilization of OCO-2data to assess crop carbon uptake and net primary productivity

California Institute of Technology- (Christian Frankenberg) evaluation of the use of solar induced fluorescence measurements to quantify crop stress in corn and soybean

Iowa State University- (Sotirios Archontoulis, Andrew van Loocke) evaluation of linkage between observed and simulated crop energy balance data for crops in the Midwest

USDA-ARS – (Jode Edwards) application of remote sensing to screening corn germplasm

Michigan State University- (Bruno Basso) evaluation of spatial and temporal dynamics in agricultural fields

US Dairy Forage Research Center- The linkage is with the ARS grand challenge project focused on how different forage production systems are linked with ecosystem services and the Upper Mississippi River Basin LTAR project.

**Support:**

NIFA, in cooperation Michigan State University and Iowa State University

NASA-Roses, in cooperation with Jet Propulsion Laboratory, CalTech, and UCLA

Climate Corp

Perfect Blend (Agrobiotics LLC)

National Pork Board

## DR. DAN B. JAYNES

*Soil Scientist*

Dr. Jaynes' contributions are in soil physics and water quality with an emphasis on determining how agricultural chemicals used in rain-fed agriculture contaminate surface and ground water and developing improved on- and off-farm management practices that exploit this knowledge to reduce contamination while maintaining farm profitability. The work involves fundamental and applied research on the movement and fate of water, nutrients, and pesticides through soils to surface water and groundwater.

**Research Goals:**

- Refine the design of saturated buffer depending on soil, landscape, and climate conditions.
- Improve the performance of woodchip bioreactors by considering factors such as age, water temperature, nitrate and dissolved oxygen concentrations, and nitrate loading rate.
- Measure the reduction in nitrate losses to subsurface drainage from planting a small grain cover crop reduces in no-till and fall-tilled corn/soybean fields.
- Compare yield and nitrate losses to the environment in typical management practices used in Iowa and highly managed practices that can use of cover crops, relay cropping, and side-dressing N fertilizer based on plant need.

**Source of Extramural Projects:**

- "Coordinated Site Network for Studying the Impacts of 4R Nutrient Management on Crop Production and Nutrient Loss", funded by Foundation for Agronomic Research and The Foundation for Food and Agriculture Research.
- "Managing Water for Increased Resiliency of Drained Agricultural Landscapes (Transforming Drainage), funded by USDA-NIFA through an AFRI grant.
- "Denitrification within Saturated Riparian Buffers Re-designed to Remove Nitrate from Artificial Subsurface Drainage", funded by USDA-NIFA through an AFRI grant.
- "Optimizing Saturated Buffer Design for Nitrate Removal from Subsurface Drainage", funded by the Iowa Nutrient Reduction Center.

**PARTNERSHIPS:**

**Coordinated Site Network for Studying the Impacts of 4R Nutrient Management on Crop Production and Nutrient Loss.**

- Matt Helmers, Professor Iowa State University
- Sylvie Brouder, Professor Purdue University
- Laura Christianson, Assistant Professor University of Illinois
- Cameron Pittelkow, Assistant Professor, University of Illinois
- Kelly Nelson, Professor University of Missouri
- John Kovar, Soil Scientist USDA-ARS
- Lowell Gentry, Research Scientist University of Illinois
- Craig Drury, Research Scientist Agriculture and Agri-Food Canada
- Fabian Fernandez, Assistant Professor University of Minnesota
- Alison Eagle, Scientist Environmental Defense Fund
- Jeffrey Volenec, Professor Purdue University
- Cliff Snyder, Nitrogen Program Director for the International Plant Nutrition Institute

**Managing Water for Increased Resiliency of Drained Agricultural Landscapes**

- Jane Frankenberger, Purdue University
- Ben Reinhart, Purdue University
- Eileen Kladivko, Purdue University
- Laura Bowling, Purdue University
- Bernard Engel, Purdue University
- Linda Prokopy, Purdue University
- Xinhua Jia, North Dakota State University
- Kelly Nelson, University of Missouri
- Matt Helmers, Iowa State University
- Lori Abendroth, Iowa State University
- John McMaine, South Dakota State University
- Mohamed Youssef, North Carolina State University
- Jeff Strock, University of Minnesota
- Brent Sohngen, The Ohio State University
- Larry Brown, The Ohio State University

**Denitrification within Saturated Riparian Buffers Re-designed to Remove Nitrate from Artificial Subsurface Drainage**

- Tom Isenhart, Iowa State University
- Tyler Groh, Iowa State University
- Moran Davis, Iowa State University
- Agricultural Drainage Management Coalition.

## *Saturated Buffers Remove Substantial Amounts of Nitrate from Tile Drainage*

**Research Team:** Dan Jaynes, Tim Parkin, and Kent Heikens, NLAE, and Tom Isenhart, Tyler Groh, and Morgan Davis, Iowa State University

**Problem.** Growing corn and soybean on land that is has artificial subsurface drains (tiles) is the leading source of nitrate in Midwest surface waters. This nitrate can increase costs to municipal and rural water providers because of the additional costs associated with nitrate removal before delivery as drinking water. This nitrate is eventually carried by the Mississippi River to the Gulf where it is the leading cause of hypoxia in the northern Gulf of Mexico – the so called dead zone. Developing sustainable farming systems that reduce nitrate losses from farmland or capture nitrate before entering streams while maintaining or increasing farm profitability is required to solve these problems.

**Approach.** We developed a new edge-of-field practice that reroutes a fraction of tile drainage as shallow groundwater within the perennially vegetated buffers planted along streams and drainage ditches. As the diverted tile drainage slowly seeps through the buffer soil to the stream, most or all of the nitrate contained in the re-routed water is removed by denitrification before entering the stream. For each saturated buffer, hundreds of pounds of nitrate can be prevented from entering streams each year. As saturated buffers are not suitable for all locations, we have also developed criteria and design aides for their proper installation.

**Application of Information and Impact.** Working with NRCS, a National Conservation Management Practice (#604) was developed for saturated buffers which allows the practice to be cost-shared by EQIP dollars. Saturated buffers are now being installed across IA, MN, IL, and OH and are gaining in their acceptance and use.

**Partners.** This research was conducted with partners from Iowa State University, the Leopold Center for Agriculture, USDA-FSA, USDA-NIFA, The Iowa Nutrient Reduction Center, and The Agricultural Drainage Management Coalition – a coalition of drainage industry companies interested in developing drainage designs and management practices that increase crop yields while decreasing nutrient losses to our Nation's waters.

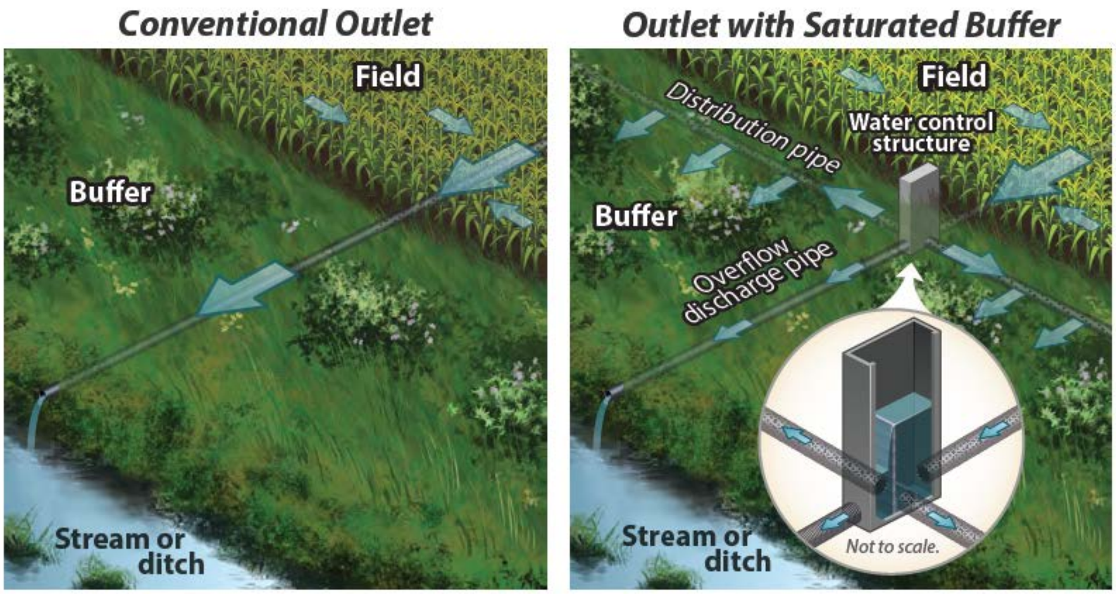



Figure 1 Schematic of a tile outlet before and after conversion to a saturated buffer (from Christianson et al., 2016).

## *Using winter rye cover crops to substantially reduce nitrate losses from corn/soybean production in the Upper Midwest.*

**Research Team:** Tom Kaspar, Dan Jaynes, Tim Parkin, Tom Moorman, Jeremy Singer, Keith Kohler, and Ben Knutson, Rob Malone, Kent Heikens, Otis Smith, and Andrea Basche, NLAE

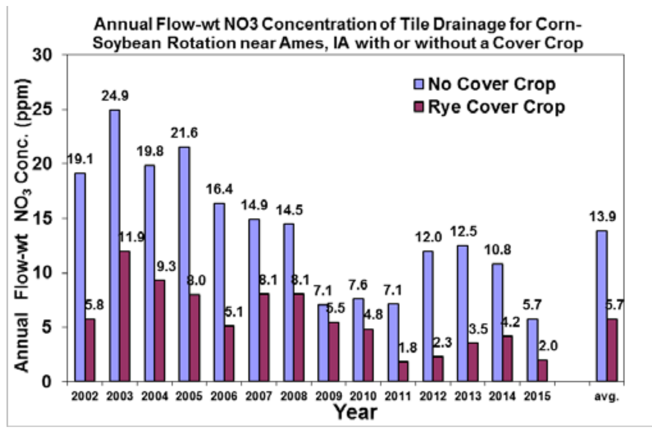
**Problem:** Much of the nitrate in the Mississippi River comes from land used to produce corn and soybean, especially if it has been drained with subsurface drainage systems. Much of this nitrate leaches from fields during the off season when no plants are present. Cover crops grown between maturity and planting of the main crop are one approach for reducing these losses of nitrate, but "common wisdom" has asserted that cover crops are not feasible in the upper Midwest due to the short growing season between main crop harvest and winter.

**Approach:** NLAE scientists proved that fall-planted cereal rye can be used as a viable winter cover crop in colder regions of Iowa. They developed methods for better planting, germination, and survival, and methods to reduce losses in yield for corn crops following rye cover crops.

Further, they showed that rye cover crops can reduce nitrate concentration in tile drainage water by 59% averaged over the 14 years. Additional research showed that a winter rye cover reduces soil erosion – even in no-till fields – and improves soil health which can lead to greater water infiltration, water availability, soil organic matter, and less variable main crop yields. Winter rye cover crops are a viable management option for reducing nitrate losses to the Mississippi River from land used for corn and soybean production even in the upper Midwest.

**Application of Information and Impact:** Due primarily to the concerted long term research program at NLAE, cover crops are now seen as a viable option in the upper Midwest and have been included as part of the nutrient reduction strategies of IA, MN, and IL. For example, farmers in Iowa are being encouraged to try cover crops by the Department of Land and Agricultural Stewardship which is offering cost share for the practice.

**Partners:** This research was conducted with partners from Iowa State University, Iowa and federal NRCS, Practical Farmers of Iowa, and Iowa Learning Farms.




*Winter rye cover crops (left) can substantially reduce nitrate losses in corn soybean rotations by taking up nitrate during the period each year between maturity and planting of the cash crops (right).*

# Dr. Douglas Karlen

*Soil Scientist*

## *Soil Health and Sustainable Bioenergy/Bio-Product Feedstock Production*

**Research Team:** Larry Pellack, Gary Radke and John Obrycki

**Problem**: Soil degradation due to erosion and soil organic carbon (SOC) loss coupled with an increasing global need for renewable, cellulosic-derived liquid transportation fuels and other bio-products have created complex natural resource management challenges that can only be solved through trans-disciplinary, multi-location research and technology transfer.

**Approach**: Research studies focused on soil health/soil quality and sustainable corn stover harvest are being conducted on large (~0.3 to 5 acre) plots and in field-scale studies. Harvest rates, tillage practices (no-till, chisel, strip), crop rotations, application of biochar, and various cover-cropping strategies have been evaluated for their productivity and soil health impacts.

**Application & Impact**: Our research program is built upon the Soil Management Assessment Framework (SMAF) developed by NLAE scientists and used nationally and internationally to evaluate soil management and land use effects on biological, chemical, and physical indicators of various soil functions. Following release of the Billion Ton Study in 2005, several multi-location soil health assessments associated with harvesting corn stover were initiated using the SMAF to help provide industry guidelines for sustainable stover harvest. Soil health assessment and sustainable stover harvest are complementary research topics because the amount of stover harvested has a direct impact on the quantity of crop residue returned to the soil as a carbon source and for protection against wind and water induced soil erosion. Our conclusions associated with this research are that:

- For central Iowa soils on near level slopes, harvesting 35% to 40% of the stover from fields yielding at least 175 bu/ac will leave sufficient crop residue to both protect soil resources and provide animal feed or bio-product feedstock.
- A SMAF analysis with three stover removal rates (0, 35%, or 60%) showed no consistent changes in soil properties, although two soil health indicators [particulate organic matter carbon (POM-C) and potentially mineralizable nitrogen (PMN)] show trends that confirm long-term monitoring is essential to ensure stover harvest practices are sustainable.
- Based on national farm operation, technology, and management data from an Agricultural Resource Management Survey (ARMS), producers who own their corn acres, harvest feed corn, do not have a predetermined end use for their corn grain, or remove residues for pest control are more likely to harvest stover than other producers. This knowledge is important for potential site selection for future bio-conversion facilities.
- A visual evaluation of soil structure (VESS) assessment showed that after seven years, neither tillage treatment (no-till or chisel) nor stover harvest rate (0, 35%, or 60%) had a significant effect on soil structural quality in Central Iowa soils.
- A recent summary of 2008 through 2016 field research on Clarion-Nicollet-Webster soils in central Iowa shows that:

- Corn grain yield was increased 10% when stover was harvested;
  - Grain yields were similar for chisel plow and no-till treatments when 35 to 60% of the corn stover was harvested;
  - Planting a cover crop did not reduce corn grain yields under no-till continuous corn; and
  - Delaying soybean planting to allow rye cover crop vegetation to be harvested for animal feed or cellulosic feedstock yielded an average of 9 tons/acre of biomass and 43 bu/acre of soybean.
- The stover harvest data also show that single-pass harvest resulted in a feedstock with an average ash content of 4% which was well within existing guidelines for bio-product use.
- Finally, after ten years of collaborative single-pass stover harvest research with Dr. Stuart Birrell (ISU Ag & BioSystems Eng.), we transitioned to the CornRower™ which significantly increased harvest speed and performed well on both large plots and in a field-scale studies associated with the Landscape Design project.

**Partners**: Department of Energy (DOE) Bioenergy Technologies Office (BETO); Antares Group Inc.; Straeter Engineering LLC.; Dave Muth EFC Systems; David Laird, ISU Agronomy Dept.; Stuart Birrell, ISU Ag & Biosystems Engineering Dept; DeAnn Presley, KSU Agronomy Dept.; Soil Health Partnership (SHP); Soil Health Institute (SHI); Foundation for Food and Agricultural Research (FFAR); USDA-NRCS Soil Health Division; National Corn Growers Association (NCGA); POET-DSM; Iowa Agricultural Biofibers (IABF); SunGrant Organization; Al Kadolph; Jane Johnson; Virginia Jin; Maysoon Mihka, Greg McMaster, and other scientists.

*2005 – Initial single-pass harvest studies*

*2008 to 2012 – Second generation protocol*

*2013 to 2015 – Third generation protocol*

*2016 to 2017 – Transition to CornRower™*

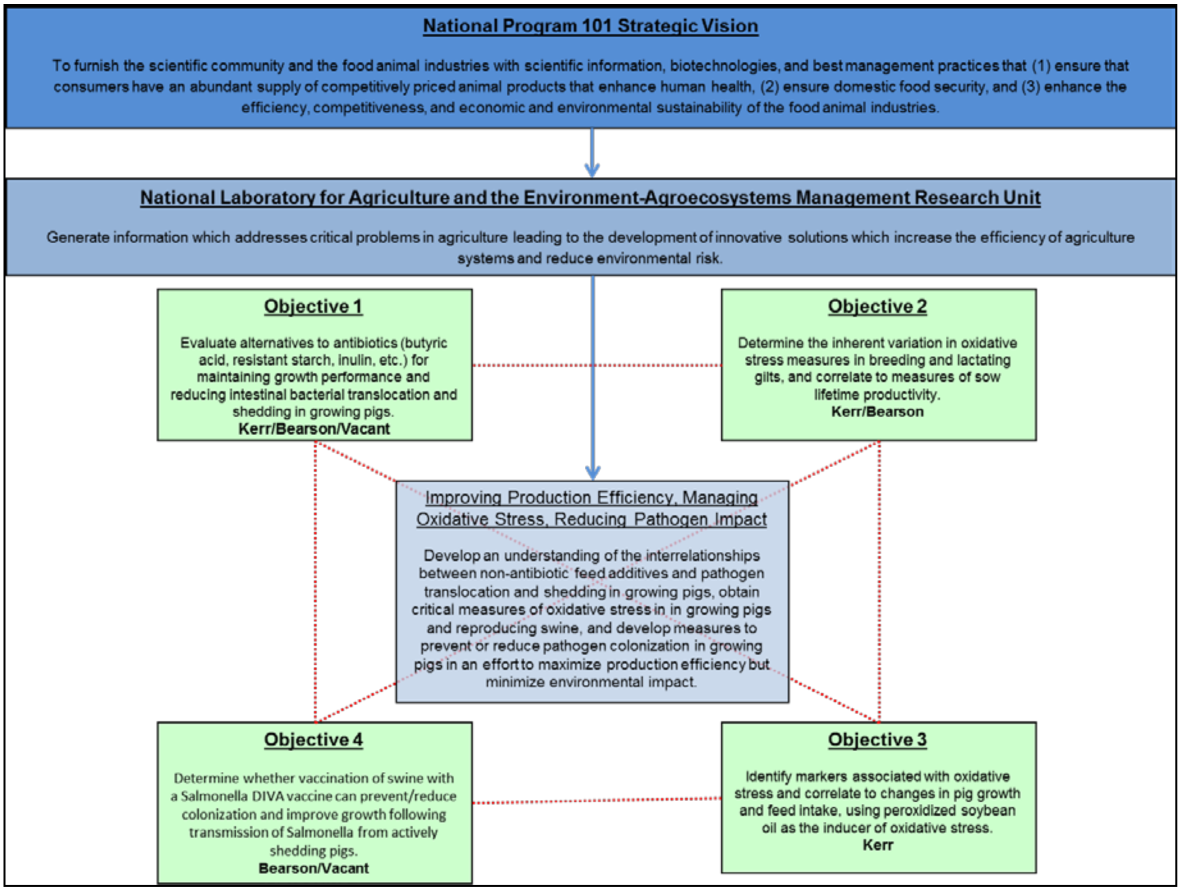
## Dr. Brian Kerr

*Animal Scientist*

**Research Mission**: Provide an understanding on how feed ingredients, additives, and other dietary inputs can be used to maintain or improve animal performance (i.e., nutrient utilization), optimize gastrointestinal health, and minimize oxidative stress; while minimizing environmental impact in a sustainable and economic manner. Within this research mission, research linkages with scientists on gastrointestinal digestive function and integrity and animal health (immune function, oxidative stress, etc.) are acquired to provide a holistic approach between nutrition, productivity, and health.

### *Reducing Production Losses due to Oxidative Stress and Bacterial Pathogens in Swine*

**Project Summary**: Antimicrobials are a critical component in the veterinary medicine arsenal for protecting health in food-producing animals. In January 2017, the FDA ban on the use of medically important antibiotics for growth promotion in animals was implemented with a requirement for veterinary oversight. Consequently, antibiotic alternatives are needed that maintain efficient animal production and reduce their susceptibility to environmental and physiological stressors. Our research response to this need assesses potential antibiotic alternatives for maintaining or improving animal productivity, monitoring biomarkers of oxidative stress, measuring changes in intestinal bacterial translocation and shedding, and determining changes in the presence of antibiotic resistant bacteria. In growing pigs, little is known on which oxidative stress and antioxidant capacity measures should be evaluated, or in which tissue they should be measured. To answer these questions, peroxidized soybean oil will be fed to growing pigs to induce oxidative stress to determine which oxidative stress and antioxidant capacity measures and which tissues are most important in this field of science. In the breeding herd, female animals need to remain in the herd for multiple parities for pork production to remain profitable and socially acceptable. Sow lifetime productivity (SLP) relates to pigs per female, per lifetime with the goal to improve SLP by 30% over the next 10 years. Even though oxidative stress and antioxidant capacity may be related to SLP, information is lacking on this relationship. Prior to designing any management or dietary means to reduce oxidative stress in an effort to improve SLP, however, information is needed to know baseline concentrations and variation of oxidative stress and antioxidant capacity measures in animals in a commercial setting. Lastly, an attenuated Salmonella vaccine will be evaluated in a pathogen transmission model in swine. Knowledge gained through this research will provide scientists, swine producers, regulatory agencies, and the consuming public valuable information to make animal production more efficient, less dependent on antibiotics, and more environmentally friendly, thereby improving the sustainability of the U.S. swine industry.




## Source of extramural projects

- Tate & Lyle: Alternatives to antibiotics on growth performance and intestinal integrity in nursery pigs
- Nutriad: Effect of short and medium chain fatty acids on growth performance and intestinal integrity in nursery pigs
- Evonic Corperation: Nutritional evaluation of animal protein by-products in growing pigs
- Kemin Industries: Thermal processing of soybean oil

**Partnerships:** Cargill Inc., DSM Animal Nutrition, Kemin Industries, Tate and Lyle, Nutriad,

**Problem #1**: Products generated from the ethanol and biodiesel industries in general have been poorly characterized and have lacked a nutritional understanding of their caloric value when supplemented to diets fed to swine and poultry.

**Approach:** Research conducted by Dr. Kerr and his colleagues has led to a comprehensive understanding of the energy value of distillers corn oil, dried distillers grains with solubles, and crude glycerin in swine and poultry industry. Based on ingredient composition, their research has generated equations to predict the energy available within the feedstuff to growing pigs and broilers for productive purposes.

**Application and impact:** While the individual caloric values of these ingredients have added to feedstuff data bases, the real value of this research is in the predictive equations generated such that livestock producers only need to know the feedstuff's composition to accurately predict its caloric value to a growing animal. Information provided by Dr. Kerr and his colleagues has led to a fuller understanding of the variation associated with biofuel co-products and allowed for a better estimation of their value to swine and poultry producers for use of these produces in feed formulation. This information has also been utilized by the producers of these products to better understand the impact of their industry on the value of the residual product produced.

**Partners:** This research has been supported by the National Pork Board, POET Nutrition, Auburn University, Iowa State University, and the University of Minnesota.

**Problem #2:** Animal production can have an impact on the environment through application of manure to cropland. Because undigested feed is the 'input' material for manure storage facilities, a greater understanding of impact of diet composition on manure composition and gas emissions is deemed vital to reducing environmental impact of animal production.

**Approach:** Research by Dr. Kerr and collaborators has focused on the impact of diet composition (protein level and source, fiber level and source, fiber level and ionophore addition, fiber level and particle size, and distillers dried grains and solubles inclusion) on manure composition and gas emissions, and on the potential for pit foaming. This research was conducted in a unique research setting where individual pigs were fed different diets with their feces and urine were collected and stored for an extended period to time to mimic manure storage facilities and delineate the impact of diet composition on manure composition and gas emissions.

**Application and impact:** This research has led to a better understanding of dietary effects on manure composition, air quality, and potential for pit foaming, which can subsequently be utilized to reduce the impact of livestock production on the environment. The data clearly show that decreasing dietary protein levels decreases manure nitrogen content and ammonia emissions. The data also show that increasing dietary fiber increases manure dry matter, nitrogen, and total and volatile solids, but results in decreased emissions of ammonia and volatile sulfur compounds. The decrease in ammonia and volatile sulfur compounds is a result of the decrease in manure pH as well as the formation of a 'crust' which generally reduces gas emissions. This information has been utilized by pork producers to better understand the impact of diet formulations on manure composition and potential gas emissions.

**Partners:** This research has been supported by the Iowa Pork Producers Council, Iowa State University, the University of Illinois, and the University of Minnesota.

## Dr. Erica J. Kistner

*Research Ecologist | Midwest Climate Hub Fellow.*

### *Project 1: Determine climate change impacts on agricultural pests, weeds, and pathogens*

Climate change has the potential to exacerbate the ongoing negative impacts that weeds, insects, and pathogens currently have on Midwestern agriculture. Additional increases in temperature and changes in precipitation will affect insect populations, incidence of crop pathogens, and weeds. Invasive species are of particularly concern because changing climate coupled with shifting trade patterns are likely to increase both the risks posed by, and the sources of invasive species. To address these issues, Dr. Kistner utilizes ecological niche modeling to determine how current conditions and future climate projections influence the distribution and abundance of key agricultural pests, pathogens, and weeds. These pest risk analyses identify regions of high establishment risk of potential invasive species based on a combination of global climate data and eco-physiological growth models. To date, her modeling work has assessed how climate change may affect the negative impacts that the invasive brown marmorated stink bug (Kistner 2017) and the superweed Palmer amaranth have on Midwestern agriculture (Kistner and Hatfield, In Review). The ultimate goal of this research is to inform pest management in light of climate change. An ecological niche model for Japanese beetle is currently being developed.

### *Project 2: Assess vulnerability of Midwestern specialty crop production to climatic variability and improve grower decision-making in a changing climate*

Increasingly variable weather and climate change pose a significant threat to the wide variety of specialty crops grown in the Midwestern United States. Specialty crops are defined as fruits and vegetables, tree nuts, dried fruits, horticulture, and nursery crops. Because specialty crops have much higher market values compared to traditional row crops, specialty crop production is an important component of the Midwest's rural economy with an estimated value of $1.8 billion dollar in annual revenue. However, these crops are more sensitive to climatic stressors and require more intensive management compared to row crops like corn. To better support Midwestern specialty crop producers, the Midwest Climate Hub, Midwestern Regional Climate Center (MRCC) and National Drought Mitigation Center (NDMC) are partnering to 1) determine which climate/weather hazards are currently impacting specialty crop production across the region, 2) assess grower capacity to deal with production risks associated with a changing climate, and 3) develop support tools and educational resources to help producers adapt to a variable and changing climate. Using USDA Risk Management Agency's regional data from 1989 to 2015 (i.e. crop insurance claims), trends in Midwestern specialty crop losses due to weather hazards were assessed (Kistner et al. 2018). We found that regional changes in temperature and precipitation are already negatively impacting Midwestern specialty crop production. Preliminary grower survey results indicate the need for crop-specific weather, production and financial risk management tools, and more accurate county-specific weather forecasts. These surveys are ongoing and are available at MRCC's website. We are planning on applying for additional funding from USDA's Specialty Crop Research Initiative in 2018 to support this work.

# DR. JOHN L. KOVAR

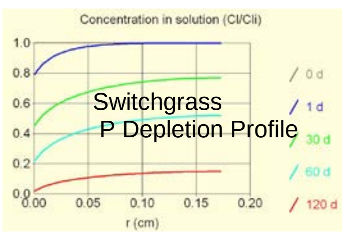
*Soil Scientist*

## *Multi-species riparian buffers capture phosphorus before it enters surface waters.*

**Research Team:** J. Michael Kelly, Virginia Tech University; Thomas M. Isenhart, Iowa State University; Michael L. Thompson, Iowa State University

**Problem:** Soil and water quality advocates have been promoting the use of multi-species grass and tree buffers to filter phosphorus and sediment from runoff and near-surface groundwater, but little quantitative data were available to support the efficacy of this practice.

**Approach:** We developed a novel micro-sampling technique (right) to quantify phosphorus depletion from soil solution by roots and were able to show that it varied greatly among plant species. We then used this information to determine the ability of plant communities within buffers to mitigate excessive levels of soluble phosphorus. Further, by utilizing a “next-generation” mechanistic nutrient uptake model (NST 3.0), we confirmed and provided quantitative information (left) documenting phosphorus by several common grass (e.g., switchgrass) and tree species. A simulation model such as NST 3.0 can provide both useful insights into the ability of various plant cover types to capture dissolved phosphorus and a means to explore which soil and plant factors are the most influential in predicting plant phosphorus uptake.




**Application and Impact:** This research provided an improved mechanistic understanding of phosphorus cycling in vegetative buffers and demonstrated the role of plant uptake in controlling phosphorus losses. We found that the addition of a fast growing woody species enhances the capture and export of phosphorus when compared to a herbaceous buffer only. We were able to document a potential 63% increase in phosphorus removal with multi-species buffers compared to single-species buffers. Several environmental groups (e.g., Trees Forever, Southfork Watershed Alliance, The Nature Conservancy, Rathbun Land and Water Alliance), Cooperative Extension agents, and NRCS personnel are using these research results to improve riparian buffer management recommendations in the upper Mississippi River Basin.

**Partners:** International Plant Nutrition Institute; Foundation for Food and Agriculture Research; Iowa State University; U.S. Geological Survey

## DR. SALLY LOGSDON

*Research Soil Scientist*

**Goal**: Determine how long-term rotations or perennial farming systems affect soil and water quality and seasonal (and off season) crop water use compared with conventional corn-soybean rotation.

Gavin Simmons: Biological technician (soils): Build and use devices to support laboratory and field research on long-term rotations and organic systems.

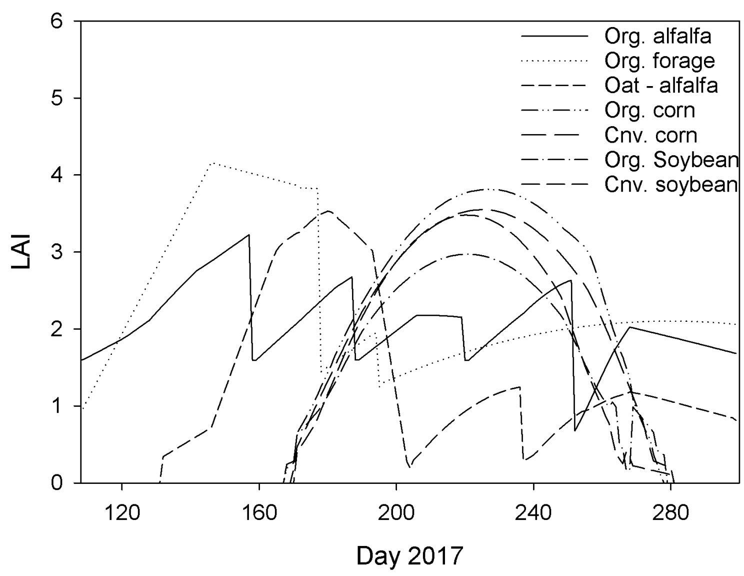
**Partnerships:** Conduct research in fields of farmers in South Fork watershed: John Gilbert and Al Uhrhammer.

**Problem #1**: Corn and soybean cropping systems do not have significant live plant cover except June through mid-September. This reduces crop use of water and nutrients, which is of concern in wet springs when excess water can result in nutrient loss in runoff and sediment, and nutrient leaching loss.

**Approach**: Using a longer term rotation and / or perennials increases the length of the growing season and crop use of water and nutrients. A 4-year organic rotation (corn, soybean, oat, +first-year alfalfa, second-year alfalfa) was compared with an organic forage and a conventional corn-soybean rotation.

**Application and impact**: The alfalfa, forage, and oat had live plant cover for 40 to >60 days before there was much corn and soybean growth, and for a few weeks after senescence of corn and soybean. In April May, and October, the organic forage (0.6, 5.0, and 1.5") used significantly more water than the combined 4-year rotation (0.2, 1.2, and 0.4"), whereas the 2-year conventional rotation did not have live crops in those months.

**Partner**: Cindy Cambardella (NLAE)



**Problem #2**: Water collecting in field depressions may reduce crop yields.

**Approach**: Soil water was measured at 16 sites, which represented different landscape positions within a field.

**Application and impact**: In a wet year, water ponded at depressional sites reducing aeration and hindering crop growth. Water continued to increase at a depressional site long after a rain event, due to sub-surface water movement from upslope. In a dry year converging landscape zones with deeper topsoil were able to provide more water to crops than diverging hilltop sites. This is important information for crop management decisions in field with depressions. Provided information to Dr. Randy Geiger (ISU-EE) and student on soil water – plant relations, who is developing low-cost field sensors.

**Partner**: Soil water and associated data has been supplied to Tom Mueller at John Deere, who is developing a GIS landscape-based approach to soil water variability within a field.

**Problem #3**: Construction in urban areas results in compacted soil, poor plant growth, and increased runoff, erosion, and loss of nutrients.

**Approach**: The first study initiated soil quality improvements on a disturbed urban soil by adding compost and planting prairie grasses. The second study added compost to existing yards.

**Application and impact**: The zones with compost and prairie grasses had significantly lower density of the surface soil, water flowed more rapidly into the soil, and there was significantly slower runoff and soil loss. Compost added to existing yards significantly reduced the density of the surface soil and improved visual soil structure without increasing runoff of phosphorus. This is important information for urban planners and land owners when developing yards on disturbed soil. Provided information to Kris Berry (urban planner 1-9-17), urban soil porosity (to urban planners Pat Sauer and Stacie Johnston 5-4-16), use of compost in urban areas (Timothy Truscott 8-5-15), and on estimating density and infiltration for urban soils (Joe Griffin, Iowa-DNR 11-11). Another collaborative urban study was done with Dr. Jan Thompson (NREM) and a student.

**Partners**: Urban land owners who participated in the second study included Aaron Crabb, Nik Gladson, Pat Sauer, and John Kovar.

## DR. ROB MALONE

*Research Agricultural Engineer*

Lead Scientist of the project "Agroecosystem Benefits from the Development and Application of New Management Technologies in Agricultural Watersheds". Research background includes integrating agricultural systems modeling with field data for investigating conservation and management practice effectiveness.

**Research goals**: 1) Develop a model to simulate N loss to drainage and alfalfa production in organic agriculture systems. 2) Investigate N loss to drainage in corn/soybean rotations with winter rye cover crop and long term climate variability.

### *Parameterization of agricultural system models*

**Problem**: With projected increases in crop production and fertilizer N use, it is important to manage cropping systems to maximize yield while minimizing N export. Models can be useful in this process to cost-effectively identify aspects of agricultural systems most in need of further study, evaluate research ideas, investigate potential solutions to agricultural problems, and support decision making. One of the most difficult and important aspects of using models is transferring knowledge of the physical processes of an agricultural system to the model and determining a set of parameter values for model application (i.e., parameterization). An exponential increase in research has been devoted to the use and development of these models over the years. Few studies, however, have been devoted to developing general parameterization guidelines to assist in model application.

**Approach**, Application, and Impact: A literature review was conducted to develop the following model parameterization guidelines: 1) use site specific measured or estimated parameter values where possible; 2) focus on the most uncertain and sensitive parameters; 3) minimize the number of optimized parameters; 4) constrain parameter values to within justified ranges; 5) use multiple criteria to help optimize parameter values; 6) use "soft" data to optimize parameters; and 7) use a warm-up period to reduce model dependence on initial condition state variables. This research contributed to the American Society of Agricultural and Biological Engineers (ASABE) developing new guidelines for evaluating and using agricultural system models (http://www.asabe.org/media/256678/ep621_pr.pdf). This research will help model users more consistently parameterize agricultural system models, which will result in 1) more accurate model simulations that are more representative of the field or watershed conditions and 2) the design of more effective management to reduce agricultural chemical transport to streams and rivers while maintaining high crop yields.

**Partners**: This research was conducted in collaboration with ARS researchers at Columbia MO (Claire Baffaut), Oxford MS (Jim Bonta), and Fort Collins CO (Tim Green), along with researchers at the USDA Forest Service (Devendra Amatya), Virginia Tech (Gene Yagow), McGill University, (Ziming Qi), Florida A&M University (Margret Gitau), and Mississippi State University (Prem Parajuli)

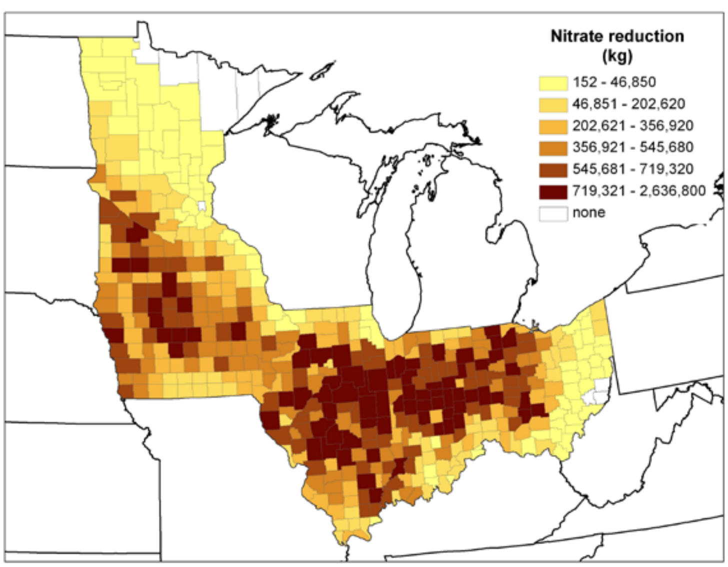
## *Modeling effects of winter cover crops on N loss to drainage*

**Problem**: Subsurface drainage under corn and soybean production in the U.S. Midwest contributes to nitrogen (N) export to the Mississippi River and hypoxia in the Gulf of Mexico. With projected increases in crop production and fertilizer N use over the next few decades, it is important to manage cropping systems to maximize yield while minimizing N export. Models can be useful to cost- and time-effectively evaluate the positive and negative aspects of conservation practices across a wide area. One of the more promising practices to reduce N loss to drainage while maintaining high crop yields is winter cover crops. Few models, however, can accurately simulate crop production, winter cover crop growth, and N loss to drainage under different weather, field management, and soils. Additionally, identifying potential revenue sources for harvested winter cover crops could increase adoption.

**Approach**: The agro-ecosystem models HERMES and RZWQM were modified to simulate drain flow and winter rye cover crop growth, tested using field data from central Iowa, and then the tested models were used to investigate cover crop systems.

**Application and Impact**: Compared with central Iowa field data, the modified models accurately simulated N loss to subsurface drainage and corn and soybean yield under both cover crop and no cover crop treatments, and the simulations agreed with field data that winter rye cover crop substantially reduced N loss to drainage. Using the tested RZWQM model, cover crop systems were found to potentially reduce nitrate loadings to the Mississippi River by approximately 20 percent. This reduction could substantially help mitigate hypoxia and support larger national efforts to reduce nitrate loads and protect water quality in the Gulf of Mexico without reducing crop yields. Simulation results from the tested model also suggest that harvesting the winter rye as a forage or bioenergy source could reduce nitrate loss to drainage even more substantially while increasing potential producer revenue and net energy per acre of the system.

**Partners**: This research was conducted in collaboration with scientists from the Leibniz-Centre for Agricultural Landscape Research in Müncheberg Germany (Christian Kersebaum), ARS laboratories in Fort Collins Colorado (Liwang Ma), St Paul Minnesota (Gary Feyereisen), and Maricopa Arizona (Kelly Thorp), and university scientists from Purdue (Eileen Kladivko), Princeton (Tim Searchinger), Penn State (Tom Richard), Iowa State (Sergio Lence), Qingdao China (Q. Fang), and Rutgers (Xenia Morin).




The average annual nitrate loss reduction from winter rye can be estimated in each county by determining the amount of land in corn and soybean production, the amount of subsurface drainage, and the RZWQM estimated nitrate reduction for corn/soybean production in that county.

**On average, RZWQM predicts that winter rye can annually reduce nitrate loss from Midwest tile drains to the Mississippi River by more than 150 million kg-N or about 20%.**

## Dr. Thomas Moorman

*Microbiologist and Research Leader*

**Research**: Presence and risk of antibiotic-resistant bacteria and zoonotic pathogens in agricultural watersheds; microbial processes in denitrification bioreactors; and development of sustainable agricultural systems. Project leader in the Upper Mississippi River Basin team in the Long-Term Agroecosystem Research Network (LTAR). Joined NLAE in 1991.

**Research Team:** Elizabeth Douglass, Biological Science Technician, Isaac Svoboda, Under Graduate Assistant

**Current External Support:**

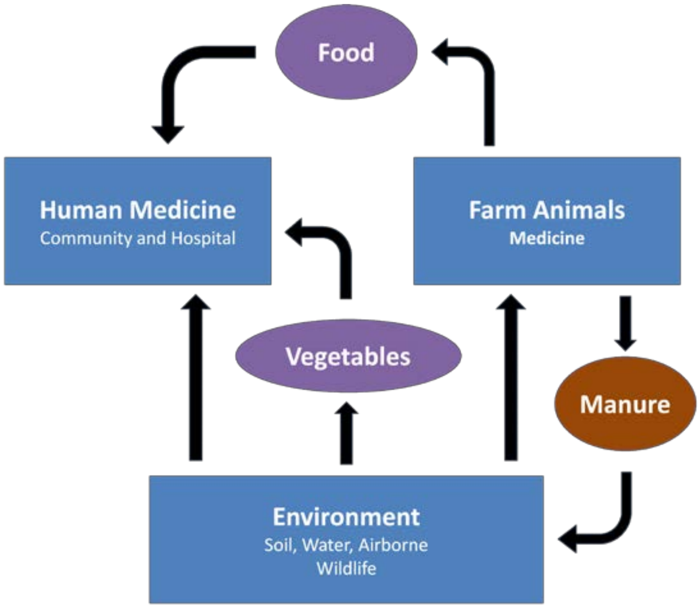
| Funding Source | Project Title | Collaborators |
|---|---|---|
| Iowa Soybean Association | Drainage water quality from manure-treated soybean crops: Bio-electrical modification of woodchip bioreactors for enhanced performance | Michelle Soupir, Natasha Hoover, Iowa State University |
| Iowa Nutrient Research Center, Iowa State University | Woodchip bioreactors for improved water quality | Michelle Soupir, Tom Isenhart, Iowa State University |
| USDA, National Institute for Food and Agriculture | Diversity of Antibiotic Resistance genes and Transfer Elements Quantitative Monitoring (DARTE-QM) for Environmental Samples | Adina Howe, Michelle Soupir, Iowa State University<br>Heather Allen, USDA-ARS<br>Shannon Hinsa, Grinnell College |
| Foundation for Food and Agriculture Research | Coordinated Network of Sites for Studying the Impacts of 4R Nitrogen Management on Crop Production and Nutrient Loss | Dan Jaynes, John Kovar, Cindy Cambardella, USDA-ARS |
| USDA, National Institute for Food and Agriculture | Stripping antibiotic resistance with STRIPS: evaluating prairie buffer strips to mitigate resistance gene dissemination from manure-amended fields | Michelle Soupir., Adina Howe, Matt Helmers, Lisa Schulte Moore, Iowa State University<br>Heather Allen, USDA-ARS<br>Diana Aga, SUNY Buffalo |
| USDA, National Institute for Food and Agriculture | Persistence of resistance: defining resistance gene and mobile element sentinels to evaluate their transmission in manure-amended soils | Adina Howe, Michelle Soupir, Iowa State University<br>Heather Allen, USDA-ARS |

## *Evaluating environmental risk from antibiotics and pathogens in swine production in fields and watersheds.*

**Problem**: Swine production in Iowa and the Midwest is an integral part of the regions productivity. However, land application of swine manure delivers antibiotics and antibiotic-resistant bacteria which may contribute to increasing difficulty with controlling due to antibiotic-resistance. The issue is complex due to multiple sources of antibiotic resistance and transport pathways and the ability of microorganisms to transfer antibiotic resistance genes from non-pathogens to pathogens in these environments.

**Approach**: We measured the off-site transport of antibiotic resistant bacteria and genes in soils and subsurface (tile) drainage water over several years at the Iowa State University Northeast Research and Demonstration Farm near Nashua, Iowa. We also made these measurements in stream and tile water over three years in the South Fork of the Iowa River SFIR). We focused on macrolide resistance genes, which make bacteria resistant to tylosin, erythromycin and azithromycin. Additionally, we measured tylosin in soil and water. Application of swine manure from a commercial barn introduced large numbers of antibiotic-resistant bacteria and genes. Over time these declined and by 12 to 24 months the resistance genes in manure treated soils were similar to soils without manure. However, in years with above average rainfall and tile drainage more resistance genes were transported in drainage water after manure application. In SFIR, tile drains had greater numbers of resistance genes than did stream waters. Tylosin was also transported through the soil to drainage water and stream water, but the concentrations were below the level that would likely select for antibiotic resistance. Measurement of fecal indicator bacteria were not predictive of the antibiotic resistance genes in drainage water or stream water.

**Application of Information and Impact**: There is a national effort to understand and the role that agricultural use plays with respect to sources of antibiotic resistance and the transmission of resistance to clinical settings. This research provided important new information on the movement of antibiotic resistance from the site of swine manure application to streams and rivers. However, this information must be combined with an assessment of potential human exposure to determine the level of risk, prior to suggesting new swine production or manure management practices.




**Movement of Antibiotics, Antibiotic-Resistant Bacteria, and Resistance Genes**

**Partners**: Our scientific partners included Michelle Soupir, Elizabeth Rieke, and Maurice Washington of Iowa State University. NLAE partners were Elizabeth Douglass, Amy Morrow, Elliot Rossow, David James, Kevin Cole, Jeff Nichols and Kelly Barnett.

Funding was provided by USDA-ARS, the USDA National Institute of Food and Agriculture, and the National Pork Board.

**DR. DAN OLK**
*Soil Scientist*

## Field Efficacy of Commercial Humic Products

**Investigators**: Dan Olk (SY), Dana Dinnes (Agronomist), Terry Grimard (Biological Science Technician), Anthony Williams (Limited Appointment)

**Problem**: Commercial humic products have been marketed for several decades. Product application is claimed to improve crop growth and economic yield. Their use has become common in specific cropping situations (potato in Pacific Northwest, tree crops in California) but remains rare for other cropping situations. Little scientific evidence exists for their broad efficacy in field conditions, and no published information exists on how their efficacy would vary by environmental conditions. Some scientific evidence exists for their modes of action in greenhouses and growth chambers, but no such evidence exists for field conditions. Yet the humic product industry continues to sell products, including considerable repeat business.

**Approach**: Our initial field studies of corn and soybean addressed the frequency of crop yield response to humic product application in on-farm conditions and identification of the growth patterns and yield components responsible for yield increases. Subsequent studies measured the impact of landscape position and soil type on crop response and the effects of product application on corn structural biochemistry, root exudates, and plant levels of hormones and anti-oxidants. Seasonal responses of corn root development were measured during three growing seasons. Integration of results from several seasons depicts the modifying effects of drought. Future research on corn and soybean will include more detailed measurements of plant physiological and biochemical processes, long-term benefits to soil health, and possible contributions of soil microorganisms to crop responses. Research sites are expanding from central Iowa to include sites in Kansas and Latin America, which will also include additional crops.

**Application of information and impact**: Our results indicated positive grain yield responses in the vast majority of field situations for corn, while soybean has shown smaller proportional responses. Multiple lines of evidence suggest humic products help crops better cope with stresses: (1) corn grain yield responses were mostly due to fewer short ears; (2) grain responses were larger in growing seasons with inadequate rainfall; and (3) corn lignification under drought conditions—a normal response—was heightened. A stress theme may help explain the lack of crop responses under ideal (or non-stressed) growing conditions sometimes reported by other researchers. We observed the loss of crop benefits at excessively high application rates, which suggests plant biostimulation as a likely mode of action, because too much biostimulation can slow plant growth. Our findings linking environmental stress with plant biostimulation will guide future research into the underlying processes. Nearly all of our measurements of corn roots found enhanced growth with humic product application, regardless of moisture stress. A general response of rooting systems to humic products would support long-term studies of humic application as an economical means to improve soil health. Overall, our studies have aided the development of an industry group, the Humic Products Trade Association. Acquired knowledge has been shared with the International Humic

Substances Society, a research organization whose national chapters, including Poland, Brazil, and Russia, are setting up new research programs in humic products or emphasizing existing programs.

**Partners:** Our field studies have been conducted in collaboration with Ag Logic Distributors (Conrad, IA), AMCOL International (Chicago, IL) now Minerals Technologies Inc. (New York City, NY), and GrowMate International (Houston, TX). Discussion of results was supported for domestic audiences by ACRES U.S.A. and Lessiter Media and for international audiences by the International Humic Substances Society.

**Problems:**

- Demonstrating whether humic products can improve corn and soybean grain yield in production fields. Stakeholders would be corn growers, humic product vendors, and researchers of humic substances and corn production
- Demonstrating whether humic products can increase corn root growth in field conditions and contribute to improved soil health. Stakeholders would be anybody interested in soil health (researchers, crop consultants, farmers) and humic product vendors.
- Explaining a yield gap in continuous rice production in Arkansas. Stakeholders would be rice producers and rice researchers. This work also contributed to developing further research in Arkansas, California, and now overseas on reducing gas emissions in rice fields through improved soil aeration.
- Helping develop more integrated procedures for extracting young fractions of soil organic matter, to better understand soil carbon accumulation and cycling. This approach has been used in field experiments with treatments that affect carbon inputs to the soil, including cover crops, heightened stover removal for ethanol production, and humic product addition. Stakeholders would be practitioners of these management practices, anybody interested in soil health, and researchers of soil carbon.

## Dr. Timothy B. Parkin

*Research Microbiologist*

### *Cover crops Improve Environmental Quality*

**Problem Statement:** Corn and soybean agriculture are a significant source of the greenhouse gas, nitrous oxide (N2O). Nitrous oxide is formed in soil when excess fertilizer or soil nitrogen is used by soil microorganisms. Winter cover crops are known to reduce nitrate leaching and improve water quality; however, confusion exists regarding the effects of cover crops on emissions of the greenhouse gas, nitrous oxide ($N_2O$).

**Approach:** The effects of a rye winter cover crop were investigated in research plots instrumented with individual tile drainage lines. The plots were established in 2000 and with a corn soybean rotation (corn in even numbered years). In the treatments plots, a rye cover crop was planted in the fall of each year: control plots had no cover crop. Throughout the period of 2004 through 2013 soil $N_2O$ emissions were measured along with nitrate loss in tile drainage water. Cumulative emissions of direct emissions of $N_2O$ from the soil were calculated over the 10-year period. Additionally, cumulative indirect emissions of $N_2O$ were estimated from tile nitrate losses using the Intergovernmental Panel on Climate Change default emissions protocol.

**Application and Impact:** Over a 10-year period we observed that both direct and indirect emissions of $N_2O$ from soil tended to be lower from the rye cover crop treatment. The cover crop was found to significantly decrease nitrate nitrogen leaching losses. This information shows that cover crops can improve water quality and not have a detrimental impact on global warming.

**Partners:** Dr. T.C. Kaspar, USDA-ARS-NLAE, Dr. D.B. Jaynes, USDA-ARS-NLAE, Dr. T.B. Moorman, USDA-ARS-NLAE

## DR. TOM SAUER

*Supervisory Soil Scientist and Research Leader*

I am the Research Leader of the Soil, Water and Air Resources (SWAR) Research Unit responsible for supervising six research scientists and providing administrative leadership and support. My personal research focus is on soil management effects on organic matter, soil health, and greenhouse gas (GHG) production. Recent studies have addressed the impacts of land use change and management of lands used for bioenergy feedstock production on soil chemical and physical properties. Ongoing long-term research includes evaluating the potential of tree windbreaks and silvopastures as climate change adaptation and mitigation practices. These studies also address potential environmental impacts of bioenergy production from crop residue and woody feedstock production.

**Partnerships:**

Alá Khaleel – M.S. student, Graduate Program for Sustainable Agriculture, Iowa State University, Ames, IA. Sources and distribution of soil organic carbon beneath tree windbreaks in the U.S. Great Plains.

Britt Moore – Ph.D. student, Department of Agronomy, Iowa State University, Ames, IA. Effect of cover crops on soil organic carbon content and plant available water.

Dr. Jerry Hatfield, Dr. John Prueger, and Dr. Christian Dold – NLAE. Surface energy balance, evapotranspiration, and GHG fluxes in agroecosystems.

Dr. Bob Horton – Department of Agronomy, Iowa State University, Ames, IA. Energy, water, and GHG transport in the soil-plant-atmosphere system of agroecosystems.

Dr. David Wedin and Dr. Andy Suyker – School of Natural Resources, University of Nebraska, Lincoln, NE. Effect of a tree windbreak on local microclimate, water and light use efficiency, and row crop productivity.

Dr. Amanda Ashworth – USDA-ARS, Poultry Production and Product Safety Research, Fayetteville, AR; Dr. Dirk Philipp, Department of Animal Science, University of Arkansas, Fayetteville, AR; Mr. Andy Thomas, Southwest Research Center, University of Missouri, Mt. Vernon, MO; Dr. Christian Dold, NLAE. Silvopasture microclimate effects on forage production and water and light use efficiency.

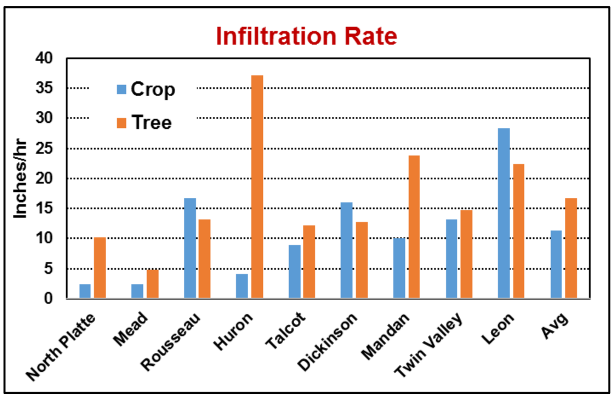
Dr. John Tyndall – Department of Natural Resources, Ecology and Management, Iowa State University, Ames, IA; Dr. Eric Brevik, Department of Natural Sciences, Dickinson State University, Dickinson, ND; Dr. Diomy Zamora, University of Minnesota Extension – Forestry, St. Paul, MN; Dr. Junyong Zhu, Forest Products Laboratory, U.S. Forest Service, Madison, WI. Woody bioenergy feedstock from marginal agricultural lands: red cedar feedstock quality and environmental sustainability.

Dr. Yury Chendev – Department of Natural Resources Use and Land Cadastre, Belgorod State University, Belgorod, Russia. Tree windbreak effects on soil carbon distribution in the U.S. Great Plains and Russian steppes.

## *Improving Soil Health of Marginal Cropland*

**Problem:** Bioenergy feedstock production can compete with food production. This competition is reduced if feedstock production is shifted to less productive "marginal" lands. There is a long history of tree windbreak planting in the U.S. Great Plains to reduce the impact of drought and protect fields from wind erosion. Our research investigates how the planting of tree windbreaks on marginal lands could produce woody bioenergy feedstock, enhance the local microclimate for crop growth, improve soil health, and provide other ecosystem services.

**Approach:** Eastern red cedar has great potential for bioenergy production due to its adaptability to a wide range of soil and climate conditions and the physical and chemical characteristics of its biomass. Nine sites were selected with annual precipitation from 16.7 to 38.1 inches and average annual temperature from 41 to 50 °F. Infiltration and soil penetration resistance were measured under the trees and in adjacent fields. Soil samples were collected for bulk density, pH, carbon, and nutrient analyses. Infiltration rates averaged 5.4 in./hr. greater and penetration resistance averaged 33 psi lower under tree cover. Tree growth was strongly related to annual precipitation with an estimated 350 lbs./Ac. increase in annual biomass for each 1 in. increase in precipitation.




**Infiltration rates beneath red cedar trees and in adjacent crop fields at nine study locations.**

**NLAE team members measuring ponded infiltration at the Rousseau, SD location.**

**Application and Impact:** This research indicate that more rainfall is likely to infiltrate beneath the red cedar trees than in the adjacent fields (row crop, hay, or pasture). Depth to root growth-limiting penetration resistance also averaged 1.4 in. greater under the trees. Increased plant available water in a deeper root zone is expected to contribute to enhanced organic matter accumulation and other improvements in soil health. The relationship between precipitation and tree growth and expected improvements in soil health will allow targeting of future plantings and potential investment in bioenergy infrastructure with the co-benefit of additional ecosystem services. These and other findings are being transferred to landowners, NGO's, and regional agency personnel through a series of extension bulletins and a field day in June of 2018.

**Partners:** This research was supported by funding from the North Central Regional Sun Grant Center at South Dakota State University through a grant provided by the US Department of Agriculture under award number 2014-38502-22598.

## DR. MARTIN SHIPITALO

*Research Soil Scientist*

I am responsible for investigating the effects of conservation practices on soil and water quality. As part of this portfolio, I conduct experiments using a plot-scale rainfall simulator to evaluate the effects of soil and crop management practices on surface water quality - independently and in collaboration with other ARS and university scientists. Current research goals include designing and evaluating conservation practices that reduce the impact of tile line surface inlets on water quality. Additionally, I am investigating the effects of corn stover harvest, poultry litter applications, and cover crops on the amount and quality of surface runoff.

**Partnerships:**

Dr. Nancy Shappell – USDA-ARS Red River Valley Agricultural Research Center, Animal Metabolism-Agricultural Chemical Research Unit, Fargo, ND. Investigating the effect of poultry litter application on losses of compounds with estrogenic activity in surface runoff under simulated rainfall.

Dr. Matthew Moore – USDA-ARS National Sedimentation Laboratory, Oxford, MS and Dr. Javier Gonzalez – USDA-ARS National Erosion Research Laboratory, West Lafayette, IN. Use of biochar to reduce herbicide losses in surface runoff and tile drainage.

SouthFork Watershed Alliance – On-farm demonstration and evaluation of the holistic Agricultural Conservation Planning Framework (ACPF) concept to site and implement stacked conservation practices.

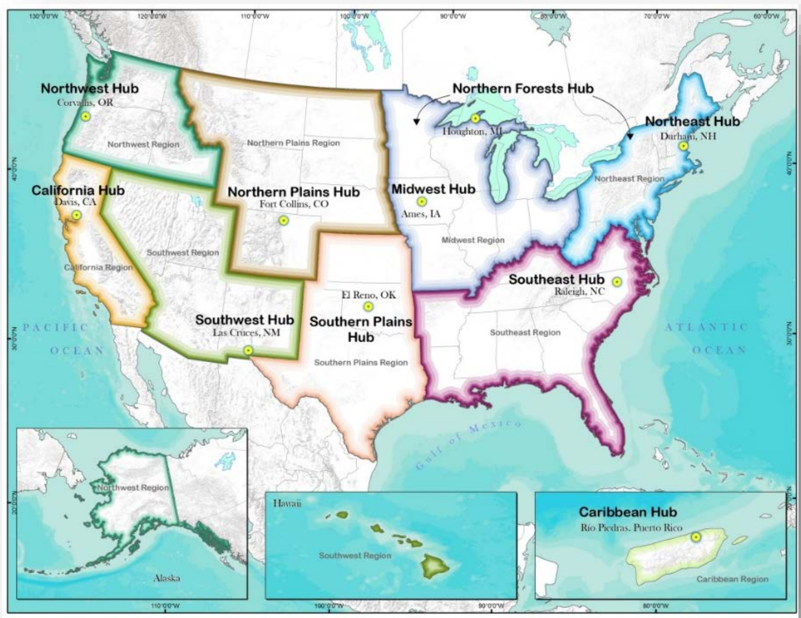
## DR. DENNIS TODEY

*Climate Hub Director*

**Research Team:** Charlene Felkley, Erica Kistner, Jerry Hatfield

Extreme weather and climate events are impacting agriculture, as well as overall climatic changes. Management practices are no longer as effective and can cause soil or nutrient loss issues. Yields are changing; management is being forced to change with it. Producers have indicated concern about numerous weather/climate related issues (see Corn CAP/U2U survey) and have indicated a need for more information about current impacts and what future conditions are likely to be. In addition, adaption strategies must be developed and made available to help producers reduce risk and thrive under changing conditions.

**Approach**: To provide information for agriculture, the Midwest Climate Hub (MCH) develops, synthesizes and delivers climate/weather information for the breadth of agriculture throughout its 8-state, Midwest region. MCH delivers information to help producers and advisors improve short and long-term decision-making in the face of large weather events and a changing climate. MCH helps develop and deliver management strategies to deal with these issues that affect agriculture. MCH gathers impact information and shares this with partners on current and potential future impacts. MCH cooperates extensively with partners to create and share pertinent ag-climate information throughout the region.




**Application of Information and Impact:** The MCH develops new information to fill gaps in the knowledge base, including future changes in yield potential, changing pest issues and new decision tools. Such work resulted in three new papers this year on the impacts of a changing climate on row and specialty crops in the region and potential pest issues in a special issue of Climatic Change (led by the hubs and edited by Jerry Hatfield). MCH staff were also authors, reviewers or otherwise contributed to the most recent National Climate Assessment.

MCH analyzes historical and current climate trends and agricultural impacts then projects how these might continue to impact agriculture. Regular releases on current conditions and outlook/impacts for agriculture supply real-time information for Midwest producers to prepare and mitigate issues.

**Two of the most utilized products from MCH were related to potential large impact events**.
**1)** In spring 2017, MCH partnered with NOAA/NWS to create a decision-support release on a large storm system, which did have wide-ranging impacts including snow damage to wheat, cattle loss, and cold and wet conditions for previously planted crops. The product was shared via the climate hubs, NWS offices and various social media outlets. The effort was applauded as a great example of early warning provided by a federal agency partnership.

**2)** Because of the 'warm late winter/early spring 2017', perennials (mainly fruit trees) broke dormancy early. MCH began meeting regularly with state extension staff to discuss potential problems and share solutions. MCH delivered outlook information to state extension staff throughout this effort. As a result, MCH has founded a regional extension system: developing a strong tie which has evolved into regular meetings about a variety of crops across the Midwest, discussing current conditions and potential future issues, and sharing information and tools across state boundaries. MCH has become a significant source of weather/climate information for various Midwest state extension services. MCH and partners continue gathering information on specialty crop needs for tools and other information to guide additional product development.


MCH partners with NOAA/NWS, state climatologists, regional climate centers and other partners on monthly outlook and drought webinars. These webinars serve 100-150 decision-makers per month and are shared with media and other stakeholders.

**Partners:**
USDA Agencies – collaborate on data/information needs and messaging to stakeholders

NOAA/NWS – cooperate on data and forecast/outlook development and sharing for agricultural stakeholders

Midwest Regional Climate Center (MRCC) - data sharing, tool development, impact reporting

National Integrated Drought Information System (NIDIS) – share information regularly on drought issues including planning and developing a regional drought early warning system.

State Extension – impact reporting, stakeholder engagement, tool development

State climatologists – stakeholder engagement, impact reporting and network collaboration

Crop/commodity groups – stakeholder engagement and product development needs.

## DR. MARK TOMER

*Research Soil Scientist*

**Research Team:** David James, Sarah Porter, Jesse Van Horn

**Research goals:** Development of planning technologies for water quality improvement in watersheds (Agricultural Conservation Planning Framework, ACPF). Determining effects of agricultural conservation practices on water quality (Conservation Effects Assessment Project, CEAP). Water quality and hydrologic assessment of agricultural watersheds.

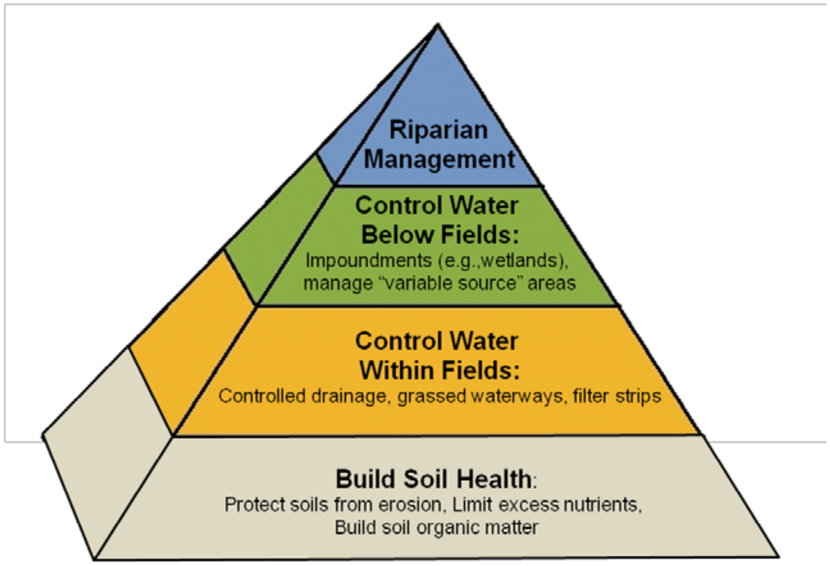
**Problem:** Midwest farmers need to reduce nutrient losses impacting water quality in the Gulf of Mexico and Great Lakes. This challenge involves the management of thousands of small watersheds comprising millions of farm fields. This means that, in order to be effective and useful, solutions must be customized to consider each landscape and farm operation.

**Approach**: The ACPF is based on a holistic planning concept that emphasizes soil health through 'soil-building' practices (e.g., minimum tillage, nutrient management, cover crops), which are emphasized without geographic emphasis or "targeting". However, in most natural landscapes under agricultural production, additional conservation practices are often needed to "trap and treat" nutrient losses at or near field edges. These practices are most effective when placed to intercept water flows where they accumulate within a watershed. The ACPF provides a GIS-based toolbox to identify those locations in agricultural landscapes where water may accumulate and that are suited for the placement of "trap and treat" conservation practices.

**Application and impact**: The ACPF toolbox uses mapped information on soil survey, land use, and high resolution elevation data to suggest suitable locations for different types of conservation practices. The results provide an 'inventory' of conservation opportunities found in fields, below fields, and in riparian zones where water quality improvement and other ecosystem services can be realized. The tools identify options to treat surface runoff and tile drainage water. A riparian classification routine is also included, which allows riparian buffer designs to be matched to streamside settings throughout a watershed. Results are not considered recommendations, but are rather a planning resource that enables local conservationists and landowners to identify preferred practices and locations suited to their own landscape and farms. ACPF watershed data are available online for >7000 small (HUC12) watersheds; data for about 2000 of these watersheds have been downloaded and watershed results are being developed and used in eight states (IA, MN, WI, IL, NE, IN, MI, and NC). The ACPF is being utilized in the implementation of Iowa's Nutrient Reduction Strategy. Further information is available through the ACPF website (www.northcentralwater.org/acpf).

**Partners**: This work has been supported by the USDA Natural Resources Conservation Service (NRCS) through the Central National Technology Center, Ft. Worth TX. We have also partnered with four land grant universities to expand the ACPF database (Iowa State University), provide on-line access to training videos, data, and user support (University of Minnesota, University of Wisconsin), and evaluate use of the ACPF and producer engagement in actual watershed planning contexts (Purdue University). These partner efforts have also been supported by the

USEPA. The ACPF effort was initiated through a collaboration on an NRCS Conservation Innovation Grant with the Environmental Defense Fund in 2011.




*A conservation pyramid that summarizes the ACPF approach to watershed planning.*

## DR. STEVEN TRABUE

*Research Chemist*

**Research Team:** Kenwood Scoggin, Physical Scientist, and Okhwa Hwang, Visiting Animal Scientist from South Korea.

**Research Goals**: Focus of our research is the reduction of gas and particulate emissions from animal production systems along various points in the production cycle from feed formulations to field applied manure with a focusing on swine production. We also have interests in microbial interactions with manure and particularly metabolism and processing of manure.

**Partnerships**: Our group partners with others at ARS, Iowa State, Iowa Pork Producers Association, and National Pork Board

### *Swine foam formation from deep-pit barns in the Midwest*

**Problem**: Foam accumulation in swine manure deep-pit barns was initially only a nuisance issue requiring increased pumping of deep-pits, but later was linked to flash fire incidents. These fires led not only to the loss of property and animals, but the death of two farm workers making swine manure foam a serious safety concern for producers.

**Approach**: Researchers from three Midwestern land grant universities along with NLAE researchers were tasked with finding root cause of foam, mitigation strategies, and what could be done to improve worker safety. Together, our groups surveyed swine barns across multiple integrators over a 13-month period collecting monthly information on a barn's foaming status along with physical, chemical, and biological properties of the barn manures. A three phase model was used to characterize the manures: 1) liquid phase (surfactant material); 2) solid phase (particles stabilizers); and 3) gas phase (biogas production). In addition, swine feeding trials were conducted to determine the role of diet formulations had on the development of foam.

**Findings**: The survey revealed that foaming manures were significantly different from non-foaming manures in two of the three phases with both particle concentrations and methane production rates significantly higher in foaming barns. This indicated that barns with foaming manure had a greater rate of foam formation and the foam that formed was more stable (i.e., drainage of liquid from bubbles was slower). The data also showed that all manures had a similar potential to foam, but non-foaming manures lacked stabilizing particles. Feeding trial data showed that fibrous diets reduced retention of nutrients resulting in increasing amounts of carbon loaded into the manure. Hence, higher carbon loading in swine manure deep pits triggered increased methane rates causing movement of biological polymers in the manure to the surface layer. These biopolymers acted as stabilizing particles with excess protein in the manure to form stable emulsions. The stable emulsions captured methane being produced more effectively creating a greater fire risk.

**Application and impact**: Poorly digestible diets high in fibrous material should be avoided in swine operations using deep-pit manure storage systems. Proteins were a key component in deep-pit foam accumulation since all deep-pits have protein levels in excess amounts requiring only stabilizing particles to create stable foam. Destabilizing the protein emulsions with enzymes and other chemicals were shown effective in reducing both the foaming potential and stability of manure. Research from this project has been presented at the Iowa Pork Congress and other pork commodity groups in Illinois and Minnesota and featured in National Hog Farmer magazine. Practical aspects of this research have been the development of safety procedures for minimizing fire hazards at swine barns.

## DR. KEN WACHA

*Postdoctoral Research Associate*

My overall research focuses on the impact that anthropogenic activity (management practices) has on soil aggregate dynamics within ag-systems by looking a collection of key landscape, hydrologic and biogeochemical processes. Some driving questions related to this research include:

- How does the resilience of soil aggregates with respect to hydrologic forcing (raindrop impact) change with respect to management and hillslope position?
- What processes impact aggregation/disaggregation within soil, and what size fractions are most stable?

To address these questions in part, current research is being conducted at both the soil column and field scale.

There is a knowledge gap in the understanding of the stability of surface aggregates against raindrop impact. To address this, I traveled to the USDA-ARS National Erosion Lab and worked with Dr. Chi-hua Huang and learned how to design and fabricate a rainfall simulator capable of simulating natural rainfall. The experimental set up includes a testing area where aggregate fractions are placed on a sieve (lower size threshold) positioned directly under the rainfall simulator. The simulator is capable of producing 16 rainfall intensities ranging from a light mist to an extreme event. A “black box” approach was used to quantify and calibrate the raindrop kinetic energy being supplied by the simulator through use of a rotating, helicopter rain gauge that relates the angular velocity to linear (vertical) velocity and the mass of collected rainfall to directly quantify kinetic energy. This allowed for repeatability of testing conditions by fixing the applied forcing to the aggregates. After rainfall is applied to the aggregate fractions the material retained atop the sieve are stable fractions and the material that passes through the sieve is the unstable, slaked fraction. This collection of rare data can have huge implications on sediment transport dynamics along hillslope flowpaths by relating unstable fractions to material entrained in the runoff.

Mesocosm experiments are being conducted within state-of-the-art growth chambers that can simulate wide ranging climatic conditions on intact soil cores (2ft diameter) collected from various ag-fields. We investigate the response of amendments and crop type to soil aggregation processes by looking changes in aggregate size distributions within the soil active layer (top 5cm) over time. Aggregate fractions are isolated to assess stability and nutrient/texture characteristics. In addition to working with the soil column scale we are temporally collecting samples in a gridded format (50mx50m) within various ag-managed fields. Here we are looking how landscape features and processes shape aggregate characteristics and how this changes in time with respect to timeline of management practices. A strong linear relation between landscape flowpath length and aggregate stability has been identified. Data from these studies is currently being used to construct an aggregation model that simulates soil aggregate dynamics in intensely managed landscapes.

Lastly, we are trying to quantify a nitrogen balance within large intact cores collected in study fields to develop an improved N-cycling model.  Pulses of N-fertilizer are applied to the columns to see how nitrogen moves through the soil.  A suite of sensors at multiple depths are wired to each column collecting continuous measurements of soil moisture and temperature (soil microclimate). At the same depths, pore water is collected at discrete time intervals with micro-lysimeters to identify corresponding nitrate concentrations.

# NLAE Projects and Multi-location Projects

## *The Conservation Effects Assessment Program*

The Conservation Effects Assessment Program (CEAP) is a joint effort between ARS at multiple locations and NRCS to determine the effectiveness of NRCS conservation practices on soil and water quality.  Water quality continues to be impacted by agricultural production and the CEAP project seeks to determine the impact of NRCS conservation practices on water quality. In the Midwest, the most prominent of these concerns are the nitrate export to the Gulf of Mexico and phosphorus loading to Lake Erie and other smaller, recreational lakes.

The NLAE contributes to by conducting watershed-scale monitoring of surface waters, by researching innovative conservation practices at the field or plot scale, and by maintaining the STEWARDS database. STEWARDS hosts weather, hydrologic, and water quality data for all 16 ARS watersheds participating in the CEAP project. These data are available to the public in Iowa; NLAE monitors changes in nitrate, phosphorus and sediment in the South Fork of the Iowa River and Walnut Creek in Story County.  Recent research addresses stream bank sediment losses in Walnut Creek, temporal patterns of nitrate transport and the impact on wood chip denitrification bioreactor design at the watershed scale, and potential implementation of conservation practices in SFIR using the Conservation Assessment Planning Framework.

Supporting research at NLAE on conservation practices to reduce nitrate losses in tile drainage includes cover crops, woodchip denitrification bioreactors, and re-saturated buffers.


*Location of benchmark watersheds in the Conservation Effects Assessment Program.*

## *The Long Term Agroecology Research Network (LTAR)*

The LTAR is a network of 18 sites that are conducting integrated research towards more sustainable agricultural systems. All sites share common concerns about business-as-usual production in their local regions, including the economic and environmental costs, tendencies toward uniform management despite varying soil and rainfall conditions, and mounting evidence of climate and other environmental changes. Comprehensively, a sustainable US agriculture would:

- satisfy domestic and international demands for food, feed, fiber and bio-energy;
- be socially acceptable and economically viable;
- protect and restore the quality of the environment and conserve its resource base; and
- enhance the quality of rural life and environments and contribute to the quality of life in the nation as a whole.

NLAE partners with ARS scientists in St. Paul and Morris, MN, and the University of Wisconsin at Platteville. We are conducting similar experiments that examine how alternative crop rotations or alternative cover crops, such as winter camelina, affect nitrate and phosphorus loss in tile drainage, soil carbon dynamics, water use efficiency and soil biology.  These alternative systems are compared to corn-soybean rotations and the corn-soybean rotation with winter rye cover crops.  Data from our experiments will be compared with data from other LTAR sites better understand nutrient and water use efficiencies to predict resilient Agroecosystems under different climate change scenarios.

## *REAP*

Several NLAE scientists and technicians have provided critical leadership and organization to an ARS Cross-Location collaboration now known as the Resilient Economic Agricultural Practices (REAP) team. Initially the acronym stood for the "Renewable Energy Assessment Project" and the team focused on cross-location research documenting impacts of various corn stover harvest rates in collaboration with several universities, private sector, NGOs, and Department of Energy (DOE) partners. Initial accomplishments include adaption and expansion of the Greenhouse gas Reduction through Agricultural Carbon Enhancement network (GRACEnet) database for REAP research information, use of those data for technical publications and industry guidelines with internal and external cooperators, and linkage of the stover harvest data to the DOE Knowledge Discovery Framework (KDF).

REAP was rebranded in 2013 as collaborations were broadened to focus on: (1) Identification of physical, chemical, or biological parameters and index tools that quantify management effects on carbon sequestration and soil health, and (2) Quantitative multi-location comparisons of business as usual (BAU) versus management practices designed to enhance soil health. Since then, the GRACEnet and REAP database successes have led to development of several other ARS cross-location teams known as: (1) "CHARNET" which focuses nationally and internationally on sustainable production and use of biochar as well as its potential for mitigating greenhouse gas (GHG) emissions and increasing C sequestration in the soil; (2) NUOnet (Nutrient Uptake and Outcome network) whose vision is for 'Efficient use of nutrients to optimize production and product quality of food for animals and humans, fuel and fiber in a sustainable manner that contributes to ecosystem services' (https://www.ars.usda.gov/anrds/nuonet/nuonet-home/); (3) AgAR (Agricultural Antibiotic Resistance) which is focusing on the details of how, and at what rate bacteria and genes move back and forth between animals and humans through agricultural systems (soil, water, air, wildlife, insects, and food) (https://www.ars.usda.gov/anrds/agar/agar-home/); and (4) an ARS Soil Biology Group which is focusing on method comparisons and meta-analyses, with the overarching goal of empowering scientists/practitioners with improved information/tools to better assess soil biological health (https://www.ars.usda.gov/anrds/soil-biology/soil-biology-home/). NLAE scientists participate in and contribute research information to all of these groups.

Additional REAP details are presented on the two subsequent pages and are also available on the ARS website: https://www.ars.usda.gov/natural-resources-and-sustainable-agricultural-systems/soil-and-air/docs/reap-2/.

## *National Program 211: Agroecosystem Benefits from the Development and Application of New Management Technologies in Agricultural Watersheds*

**Investigators**: Rob Malone (lead), Jerry Hatfield, Dan Jaynes, Sally Logsdon, Tom Moorman, Martin Shipitalo, Mark Tomer

**Partnerships**

Dr. B. Tom Nolan, USGS, Reston, VA. Used agro-ecosystem models, neural networks, and field data from USGS and ARS to quantify nitrate and pesticide fate across the U.S. corn-belt under several management conditions.

Dr. Christian Kersebaum, Leibniz Centre for Agricultural Landscape Research (ZALF), Müncheberg, Germany. Modified the HERMES agro-ecosystem model to nitrate loss to subsurface drainage under corn-soybean-rye cover crop rotations and compared to field data from central Iowa.

**Project Summary**

The overall goal of this project is to develop practices, technologies, and approaches that can deliver long-term water quality improvement and other agroecosystem services through agricultural conservation practices. Promising practices have been developed to improve subsurface drainage discharge water quality such as extended crop rotations and perennial systems, cover crops, organic systems, and edge of field technologies such as vegetative drainage outlets (saturated buffers), drainage outlet bioreactors, and buffering of surface inlets to subsurface drainage. Critical research questions remain, however, which include the life expectancy of these systems and their effectiveness under a wide range of soil, management, climate conditions, and filter material. Also, more economically viable/beneficial cover crop practices need to be developed that reduce Nitrogen (N) loss to subsurface drains. For conservation practices such as these to be most effective, they need to be placed in the proper location in watersheds and tools to assist with this complicated task need to be tested and improved. Animal production is common in the Midwest and the land application of animal manure is an important method of recycling nutrients. With increased food demand and the associated increased use of antibiotics in animal production, knowledge gaps need to be addressed such as antibiotic fate in manured farmlands and the interaction of antibiotic fate-controlling processes such as sorption and degradation at the field scale. We will address these concerns through watershed, field, laboratory, and modeling studies. Knowledge gained through this research will provide producers and agencies data and tools to improve agricultural decisions and water quality, particularly in the Upper Mississippi River Basin (UMRB).

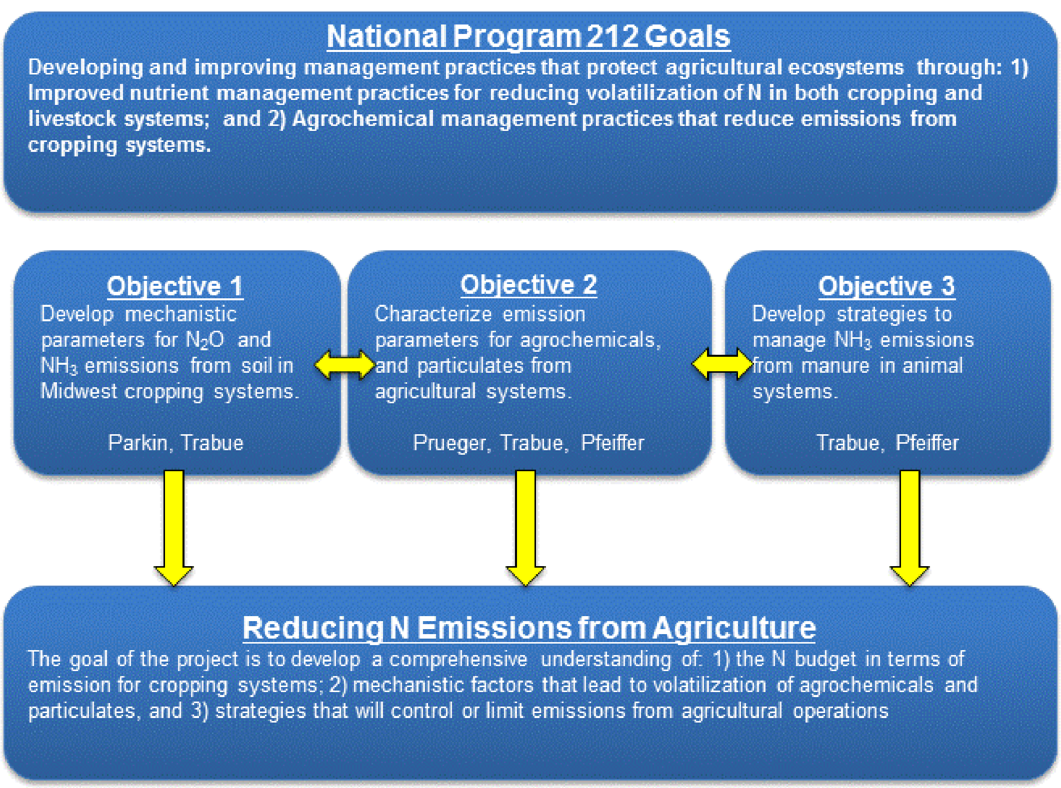
**Research questions for each objective, and spatial scale(s) each question is being addressed.**

| Arena of watershed research | OBJECTIVE | Research questions driving sub-objectives | Spatial scale(s) questions will be addressed | | |
|---|---|---|---|---|---|
| | | | Landscape to Field Scale | Riparian, Aquatic and River | Watersheds and Regions |
| Management and application | 1. Conservation practices and planning tools | 1.1 What water quality improvements can be gained from conservation practices in artificially drained landscapes? | ☑ | ☑ | |
| | | 1.2 What water quality improvements can be gained from integration of perennials into crop rotations? | ☑ | | |
| | | 1.3 How can conservation planning tools be used to better identify options to improve water quality in watersheds? | | | ☑ |
| Dynamics of agro-ecosystems | 2. Watershed and LTAR research | 2.1 How are watershed hydrology and water quality responding to changes in climate and agricultural practices? | | | ☑ |
| | | 2.2 How can agricultural systems be improved to enhance sustainability and ecosystem outcomes? | ☑ | | |
| | | 2.3 Can new databases enhance networking among agricultural scientists and inform an economically competitive and environmentally adaptive agriculture? | ☑ | ☑ | ☑ |
| Basic knowledge | 3. Fate/behavior of antibiotics and resistance genes | 3.1 How can soil and climatic information help us identify risks of off-site transport of antibiotics and antibiotic resistance? | ☑ | | |
| | | 3.2 What determines the persistence of antibiotics and antibiotic resistance in receiving aquatic systems? | | ☑ | |
| | | 3.3 Can simulation models predict the fate, transport, and persistence of antibiotics and antibiotic resistance? | ☑ | | |

## *National Program 212: Reducing the Environmental Footprint from Agricultural Systems through Managing Resources and Nutrient Inputs*

**Investigators**: Steven L. Trabue (Lead), Timothy B. Parkin, John H. Prueger

Nitrogen (N) is an essential nutrient in agricultural systems, but it is reactive and transforms into various species that are highly mobile and susceptible to loss from the system if not properly managed. Reactive N species lost through atmospheric emissions include ammonia (NH3), nitrous oxide (N2O), and N oxides (NO and NO2). Gaps exist in our understanding of the N biogeochemical cycle and its volatilization that limit our ability to develop effective N management practices. In cropping systems, there are large gaps in our understanding of the N budget in soil including both mechanisms and magnitude of losses through emissions. Gaps also exist in quantifying the transport parameters controlling volatile losses of N compounds from field and animal production facilities. In animal production systems, NH3 is the dominant form of N emissions, but gaps exist in effective N control/mitigation strategies that reduce N emissions. These gaps in information have limited the ability to successfully reduce the environmental impact of N emissions from farming practices. Three approaches are to be pursued to address these concerns: 1) quantify soil and environmental factors contributing to N2O and NH3 emissions in laboratory and field cropping systems; 2) determine soil properties that drive volatile loss and transport of agrochemicals and N compounds from agricultural systems, and 3) deter mine effectiveness of N control strategies for reducing NH3 emissions from swine production. Knowledge gained through this research will provide producers tools to improve agricultural production facilities sustainability in U.S. farming systems.



## *National Program 212: Managing Carbon and Nutrients in Midwestern U.S. Agroecosystems for Enhanced Soil Health and Environmental Quality.*

**Investigators**: Daniel C. Olk (Lead), Douglas L. Karlen, Martin J. Shipitalo (50%)

Improving our understanding and management of soil carbon will help sustain the quantity and quality of soil organic matter (SOM), increase agricultural productivity, and improve the efficiency of nutrient cycling. It will also improve crop residue management practices and provide science-based information about carbon-based soil amendments. Laboratory analyses for specific carbohydrates, amino compounds, phenols, and fatty acids are being used to distinguish younger, more active and decomposable fractions of SOM from older, more resistant fractions. This approach provides us more precise information regarding SOM responses to short-term crop management practices. For example, our use of young SOM fractions and marker compounds detects the capabilities of various humic product or cover crop treatments to alter short-term nutrient cycling as well as long-term carbon sequestration, and more precisely than can total organic carbon measurements. Quantifying specific compounds in younger SOM fractions also provides a better understanding of SOM formation from crop residues and potentially other types of carbon-based soil amendments (e.g., manure, municipal solid waste).

Studies designed to protect water quality from agricultural runoff and prevent soil carbon loss due to erosion are also being conducted. Filter socks filled with wood chips and bark are being evaluated as a means to efficiently catch dissolved and sediment-bound phosphorus moving with runoff water into surface inlets, subsurface drainage systems, and ultimately natural water bodies. The filter socks also prevent sediment from entering subsurface drainage lines through drop inlets at the soil surface.

Process-level knowledge from laboratory-, plot-, and field-scale research is being used to enhance development of site-specific subfield management strategies for increasing producer profitability and providing sustainable feedstock supplies for bioenergy and bio-products. Several different crop rotations with corn, soybean, alfalfa, wheat, cereal rye, field pea, and tillage radish are being evaluated with various levels of corn stover and rye biomass harvest. No-tillage, strip-tillage, and chisel-plow management as well as effects of biochar are included in the studies. Effects on nutrient cycling, soil carbon stocks, and soil health [using the Soil Management Assessment Framework (SMAF)] are being quantified. Project results will provide critical information needed to better understand effects of crop residue management and carbon-based amendments on soil physical and biochemical properties, economic returns, and long-term sustainability of corn-based Midwestern cropping systems.

**Funding Sources of Extramural Projects:**

Ag Logic Distributors

Agricultural Technology Innovation Partnership Foundation

GrowMate International

Iowa State University

Leopold Center for Sustainable Agriculture

Minerals Technologies Inc.

South Dakota State University

Straeter Innovation Inc.

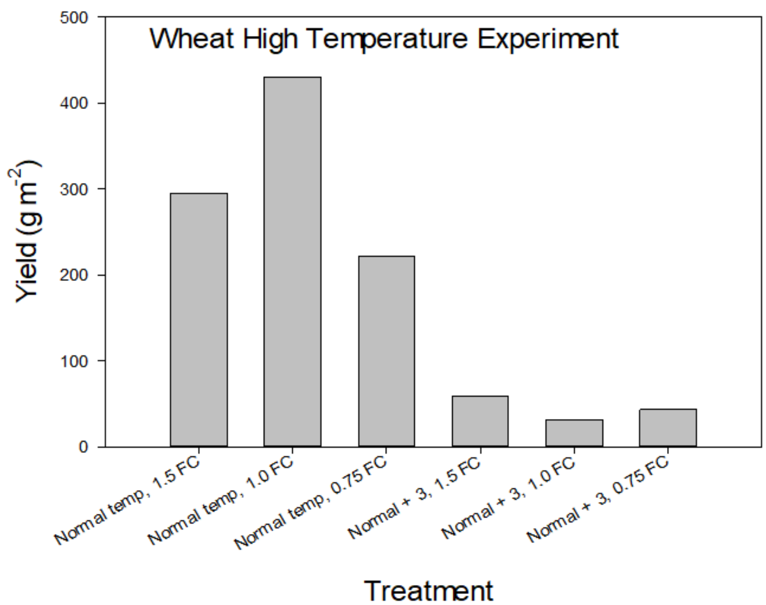
U.S. Department of Energy

National Corn Growers

## *National Program 216: Utilization of the G x E x M Framework to Develop Climate Adaptation Strategies for Temperate Agricultural Systems*

**Investigators**: Jerry L. Hatfield and Thomas J. Sauer

**Objective 1**: Evaluate the impact of temperature and soil water stress on germplasm of corn, soybean, and wheat Studies were conducted on the effect of high temperatures on corn and wheat growth, phenology, and gran yield using the rhizotrons at NLAE. The corn study utilized three different corn hybrids from three eras of corn breeding exposed to normal Ames temperature (1981-2010 normals) compared to normal plus 4°C with all hybrids maintained at field capacity of soil water to reduce any interaction with soil water deficits. These results showed that the higher temperatures dramatically reduced grain yields because of the exposure to the high minimum temperatures during the grain-filling period. A recent study was initiated on winter wheat using a single variety of wheat growing under Salina, Kansas normal temperatures (1981-2010) and normal + 3°C under three soil water regimes, 1.25 field capacity, 1.0 field capacity, and 0.75 field capacity. The preliminary results showed there was an effect on number of tillers, the size of the ears, and the grain yield with a negative effect of temperature across all soil water regimes. Water limitations increased the high temperature impacts.




**Objective 2**: Quantify the interactions of water and temperature stresses on energy and C exchanges in corn and soybean fields under different management systems.

We have used our long-term observations of energy fluxes coupled with canopy temperature measurements over corn and soybean canopies to evaluate the interaction of water and temperature stresses. The variation of temperature and precipitation during the course of a growing season provide a natural experiment to examine these interactions. We have used canopy temperatures incorporated into the crop water stress index to quantify the amount of water stress in the corn and soybean canopies. We found there are periods during each growing season where the corn and soybean crop is subjected to water stress and this reduces the net primary productivity for that day. The effect on the reduction in net primary productivity is directly linked to water deficits. One notable observation is when the minimum temperatures are above the upper threshold, there is a rapid increase in respiration during the night and a dramatic reduction in net primary productivity. CO2 concentrations measured within the canopies show extremely large pools of CO2 which equate the amount of uptake during the previous day. These high minimum temperatures lead to an increase in the rate of phenological development and reduce the length of the grain-filling period. These data are being summarized across growing season to show the effect of minimum temperatures on the efficiency of the grain-filling process in corn and soybean and provide documentation for why the increase in temperatures during this period is detrimental to grain yield in the Midwest.

**Objective 3**: Describe the relationships between ground-based and satellite observed water use and net primary productivity across the Upper Midwest and California.

A long-term database of ground-based remote sensing observations has been assembled for corn, soybean, canola, wheat, and barley for the Midwest. These data have been used to refine the relationship between vegetative indices and various plant growth parameters, e.g., leaf area index, ground cover, light interception, biomass, and phenology development. One of the relationships we discovered was being able to define the growth pattern in corn into vegetative and reproductive stages of development. This has been a question raised by NASS (National Agriculture Statistics Service) for their continued expansion of the utility of remote sensing in estimating agricultural production and the relationship is being evaluated for its robustness among years. Another aspect that is being evaluated with the ground-based observations is what frequency of observation is needed to detect a given change in a plant parameter that will give confidence in the ability to assess the changes across large areas. Data bases of MODIS and LandSat are being assembled for the upper Midwest to link to the Upper Mississippi River Basin LTAR. Relationships between the gross and net primary productivity are being evaluated using combination of vegetative indices.

**Objective 4**: Evaluate agroforestry practice effects on local microclimate, and on crop and forage production, C sequestration, and greenhouse gas production.

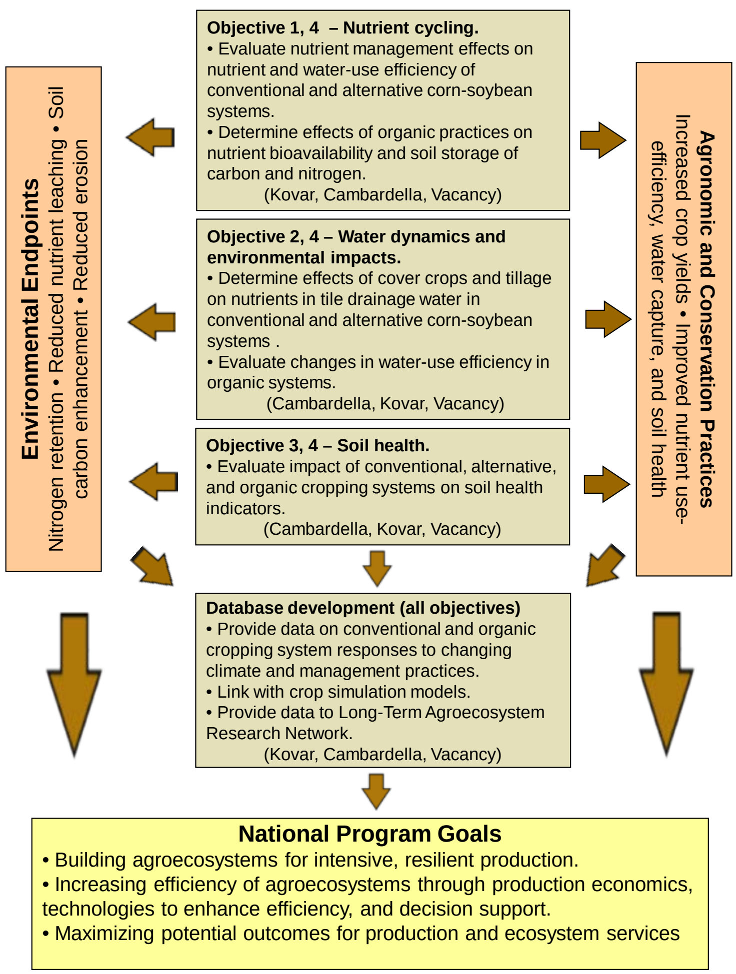
Preliminary yield results for the open and sheltered corn at Mead indicated a ~1255 kg ha-1 (20 bu A-1) higher yield in the sheltered field. Some of this difference may be due to ear drop in the open field caused by high winds. Although yield maps indicate decreased yield near the windbreaks, this yield loss was compensated for by higher yields near the center of the sheltered field. Average soil CO2 flux measurements in the windbreak and field averaged 2.64 and 1.75 umol m-2 s-1, respectively. This difference is attributed to drier soil conditions in the field and a later of cedar leaves on the soil surface inside the windbreak. Biomass and C content of the oak and pecan trees was estimated following destructive sampling of seven oak and seven pecan trees. The leaves, branches, and trunk were weighed and samples taken for C analyses. Growth curves were prepared to enable estimation of standing biomass and C content of all oak and pecan trees based on diameter at breast height (DBH).

## *Sustainable and Resilient Cropping Systems for Midwestern Landscapes*

**Research Team:** John Kovar (Lead), Cindy Cambardella, Tom Kaspar (retired)

**Overview**: Degradation of soil health and water quality in the upper Midwest is partly attributed to the intensive production of corn and soybean. This project addresses soil and crop nutrient cycling and losses in three production systems, including a conventional corn-soybean rotation, an alternate conventional system that includes cover crops and relay cropping, and an organic system with extended crop rotations. Specifically, we are investigating the effects of 4R management of nitrogen (right amount, source, placement, and timing) on nutrient cycling in corn-soybean systems, the ability of cover crops to reduce nitrate losses and maintain soil health in corn-soybean systems, and the efficacy of organic cropping systems to reduce nitrate losses and enhance soil health. The goal of this project is to develop technologies to manage Midwestern cropping systems that improve water quality and enhance soil health while maintaining economic viability.

**Objectives**: Controlled experiments in the field and laboratory, tile drainage monitoring, and a variety of modeling techniques and statistical analyses are being employed in pursuit of the objectives outlined below.



**<u>Extramural Projects:</u>**

**Collaborator:** International Plant Nutrition Institute; Foundation for Food and Agriculture Research

Coordinated Site Network for Studying the Impacts of 4R Nutrient Management on Crop Production and Nutrient Loss

**Collaborator**: Iowa State University
Processes Controlling the Source, Movement, and Release of Soil Phosphorus in Midwestern Streams from Pasture and Crop Land

Cover Crops Influence Nutrient Cycling, Yield, and Diseases of Corn and Soybean
Phosphorus Contributions from Eroding Iowa Stream Banks
Cover Crops Influence Nutrient Cycling, Yield, and Diseases of Corn and Soybean
Linking Soil and Water Quality with Crop Performance Across a Continuum of Tillage and Management Strategies

**Collaborator**: U.S. Geological Survey

Soil Carbon Cycle Science in Reconstructed Tallgrass Prairie Ecosystems

**Collaborator**: Koch Biological Solutions, LLC

Evaluation of Biological Amendments on Photosynthetic Rates and Water Use Efficiency of Corn, Soybean, and Wheat

**Collaborator**: Calcium Products, Inc.

Evaluation of Methods to Determine Efficacy of Liming Materials Applied to Agricultural Soils

## *National Program 301: Reducing Production Losses due to Oxidative Stress and Bacterial Pathogens in Swine*

**Research Team**: Brian J. Kerr, Brad Bearson

**Project Summary:** Antimicrobials are a critical component in the veterinary medicine arsenal for protecting health in food-producing animals. In January 2017, a Food and Drug Administration (FDA) ban on the use of medically important antibiotics for growth promotion in animals was implemented with a requirement for veterinary oversight on the therapeutic use of medically important antibiotics. Consequently, antibiotic alternatives are needed that maintain efficient animal production and reduce their susceptibility to environmental and physiological stressors. Our research response to this need assesses potential antibiotic alternatives for maintaining or improving animal productivity, monitoring biomarkers of oxidative stress, measuring changes in intestinal bacterial translocation and shedding, and determining changes in the presence of antibiotic resistant bacteria. In growing pigs, little is known on which oxidative stress and antioxidant capacity measures should be evaluated, or in which tissue they should be measured. To answer these questions, peroxidized soybean oil will be fed to growing pigs to induce oxidative stress to determine which oxidative stress and antioxidant capacity measures and which tissues are most important in this field of science. In the breeding herd, female animals need to remain in the herd for multiple parities for pork production to remain profitable and socially acceptable. Sow lifetime productivity (SLP) relates to pigs per female, per lifetime with the goal to improve SLP by 30% over the next 10 years. Even though oxidative stress and antioxidant capacity may be related to SLP, information is lacking on this relationship. Prior to designing any management or dietary means to reduce oxidative stress in an effort to improve SLP, however, information is needed to know baseline concentrations and variation of oxidative stress and antioxidant capacity measures in animals in a commercial setting. Lastly, an attenuated *Salmonella* vaccine will be evaluated in a pathogen transmission model in swine. Knowledge gained through this research will provide scientists, swine producers, regulatory agencies, and the consuming public valuable information to make animal production more efficient, less dependent on antibiotics, and more environmentally friendly, thereby improving the sustainability of the U.S. swine industry.

**Objectives:** to develop an understanding of the interrelationships between non-antibiotic feed additives and pathogen translocation and shedding in growing pigs, obtain critical measures of oxidative stress in growing pigs and reproducing swine, and develop interventions to reduce or prevent pathogen colonization and disease in swine in an effort to maximize production efficiency but minimize environmental impact.

**Objective 1:** Evaluate alternatives to antibiotics (butyric acid, resistant starch, inulin, etc.) for maintaining growth performance and reducing intestinal bacterial translocation and shedding in growing pigs.

**Objective 2**: Determine the inherent variation in oxidative stress measures in breeding and lactating gilts, and correlate to measures of sow lifetime productivity.

**Objective 3**: Identify markers associated with oxidative stress and correlate to changes in pig growth and feed intake, using peroxidized soybean oil as the inducer of oxidative stress.

**Objective 4**: Determine whether vaccination of swine with a *Salmonella* DIVA vaccine can prevent/reduce colonization and improve growth following transmission of *Salmonella* from actively shedding pigs.

# NLAE Current and Past Employees

## *NLAE Staff*

***Mindy Barber***, ***Program Support Assistant***. Member of the NLAE Administrative Team, providing a wide variety of Administration support and assistance to the Laboratory Director including travel, meeting planning, agreements, and ensures the wellbeing of NLAE in all aspects. Joined NLAE in January 1998.

***Kelly Barnett***, ***Agricultural Science Technician***. Responsible for collecting and processing hydrological and meteorological data from stream and tile monitoring sites located within three research watersheds. Joined NLAE in March 2004.

***Bradley L. Bearson***, ***Microbiologist***. Investigation of *Salmonella* colonization and pathogenesis in food-producing animals including swine and turkeys. Development and evaluation of alternatives to antibiotics, such as vaccines or other targeted interventions against *Salmonella*. Joined NLAE in September 2001.

***Jay Berkey, Agricultural Science Technician. C***ollects and processes samples and data from field and laboratory experiments, coordinate experiment logistics and foster teamwork and communication, maintain laboratory and field facilities, and participate in research planning and project development. Joined NLAE in January 2000.

***Taylor Berkshire, Pathways Program: Student Biological Trainee.*** Assists in the maintenance of various experiments within NLAE's Agroecosystem Management Research Unit. Collects and processes plant and soil samples from the experiments. Joined NLAE in February 2015.

***Brian Boon, IT Assistant.*** Assists in the maintenance and operation of hardware and software for the NLAE IT systems. Joined NLAE in 2016.

***Lori Burma***, **Program Support Assistant**. Member of the NLAE Administrative Team, specifically assigned to the Agroecosystems Management Research Unit, providing support and assistance in all areas of administration, including travel, budget, personnel, and agreements. Joined NLAE in April 2007.

***Kelli Byriel, Physical Science Technician (L/A).*** Responsible for collection of hydrological and meteorological data for watershed research, processing sediment concentration sampling, and maintenance of lab and field equipment. Joined NLAE in May 2014.

***Cindy Cambardella, Soil Scientist***. Conduct research at the interface of soil science and ecology, where I explore how changes in climate, land-use and agricultural management impact soil and water quality by improving our understanding of the interrelationships among plant roots, soil organic matter, soil structure and the cycling of C and N in natural and managed ecosystems. Joined NLAE in December 1991.

***Derek Carney***, ***Agricultural Science Technician*** **(TERM).** Manages field aspects of several experiments that evaluate agroecosystem response to alternative agricultural practices. Collects soil, compost, and plant samples and measures $CO_2$ flux during the growing season, and collects water samples year-round from two field sites. Joined NLAE in March 2013.

***Danielle Churchill, Physical Science Technician***. In the Analytical Laboratory, subsampling and extracting soil and plant samples that will be analyzed for Nitrate and Ammonia using Flow Injection Analysis, subsampling and extracting soil samples for Inorganic Carbon, subsampling water samples and providing general maintenance for the analytical laboratory. Joined NLAE in April 2002.

***Kevin Cole, Physical Scientist***. Manage water quality monitoring activities at three large research watersheds which focus on nutrient transport. Maintain stream and tile flow monitoring stations. Database manager for NLAE water quality projects in Iowa and across the ARS CEAP watersheds. Joined NLAE in May 1995.

***Jeff Cook, Engineering Technician***. Technician working with projects to evaluate methods to improve water quality of run-off entering field tile surface inlets. Joined NLAE in April 1989.

***Jennifer Cook, Biological Science Technician***. Conduct the biochemical analyses in support of Dr. Brian Kerr's research of issues facing the animal production industry. Joined NLAE in February 1999.

***Michelle Cryder, Agricultural Science Technician.*** Collect and summarize agricultural crops and climate data across the Midwest to analyze crop responses to weather and climate variation. I create databases and perform statistical analyses for eight states as part of the Midwest Climate Hub project. Joined NLAE in March 2013.

***Shelby Curry, Animal Physiologist (ORISE Post-doc).*** Investigates the effect of modified diets in animals that affect their performance and functionality of the gut. Joined NLAE in 2017.

***David DenHaan, Physical Science Technician***. Provides analytical services for NLAE focusing mainly on carbon and nitrogen analysis, elemental analysis by Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES), and Isotope Ratio Mass Spectroscopy (IRMS) of carbon and nitrogen. Joined NLAE in March 1998.

***Dana L. Dinnes, Agronomist***. Assists Category 1 Scientists with establishing research experiment goals, objectives and action plans; assists with field and greenhouse research experimental designs; conducts and directs research operations and measurements; performs statistical analyses; writing of data summaries, project reports, technology transfer materials, and research manuscripts; and, seminar presentations at scientific and public conferences. Joined NLAE in October 1996.

***Christian Dold, Plant Physiologist (Post-Doc).*** I investigate the amount of carbon assimilated, respired and stored by corn, soybean, and native prairie vegetation for the period of 2006-2015. The results will be partly used for validation of satellite based measurements of $CO_2$. I also investigate the efficiency of novel foliar application agents to boost yields in corn, wheat, and soybean under controlled conditions (growth chamber, rhizotron) and in field experiments. Joined NLAE in January 2015.

***Beth Douglass, Biological Science Technician***. Conducts biological, chemical and molecular analyses to support Dr. Tom Moorman's research of antimicrobial resistant microorganisms and genes in agricultural soils and water systems as well as his water quality research studying the denitrification potential of field scale bioreactors. Joined NLAE in October 1991.

***Diane Farris, Physical Science Technician.*** Provides analytical service for NLAE testing water samples for ammonia, nitrate, orthophosphorus, total phosphorus, and total dissolved phosphorus using Lachat Instrumentation (flow injection analysis). Joined ARS in August 1987.

***Charlene Felkley, Coordinator, Midwest Climate Hub***. Works to improve access to usable climate and ag-based resources to stakeholders and producers in the Midwest Region. She ensures the right information is getting to the right people at the right time. Joined NLAE in 2016.

***Forrest Goodman, Agricultural Science Technician***. Collect and maintain data from a network of weather and Eddy Covariance stations for use in micrometeorological research of agriculture systems. Joined NLAE in April 1998.

***Terry Grimard, Biological Science Technician***. Analyze various plant, soil, and soil fractions for amino acids, carbohydrates, and phenols. Joined NLAE in October 2004.

***Laura Hansen, Biological Science Technician.*** Help collect and analyze information the laboratory generates which addresses critical problems in agriculture. Joined NLAE in September 2015.

***Jerry Hatfield, Laboratory Director and Supervisory Plant Physiologist***. Responsible for the leadership of National Laboratory for Agriculture and the Environment, interactions with stakeholders, and a personal research program focused on quantifying the interactions among components of the soil-plant-atmosphere continuum. Serves as the Location Coordinator for the Ames Location. Member of the ARS Hall of Fame. Joined ARS in June 1983.

***Valerie Hedlund, Office Automation Assistant***. Process 115 publication submissions. Conducts the sign-in procedure for NLAE visitors. Ships and receives in the mailroom, and serves as the office receptionist. Joined NLAE in 2015.

***Kent Heikens, Agricultural Science Technician***. Conducting field scale, small plot, and lab research in the areas of soil compaction, nitrogen management, nutrient reduction strategies, and field tile drainage techniques as they relate to production agriculture. Joined NLAE in January 1990.

***Dave James, Geographic Information Specialist***. My position within ARS is directed toward gaining a scientifically-sound understanding of the principles of spatial data analysis and information management in support of agricultural research. I design and conduct projects to develop spatial data handling processes and products to foster the use of GIS technology within Laboratory and Agency programs and for inter-agency projects. I work with Agency staff to incorporate the use of GIS technology into existing ARS research programs through the development of custom applications support. Joined NLAE in September 1996.

***Bob Jaquis, IT Specialist***. Troubleshoot and resolve problems with the hardware and software to keep network resources available for NLAE staff. Plan for upgrades and replacements to improve network performance. Joined NLAE in January 1993.

***Dan Jaynes, Soil Scientist***. Conducts research quantifying the complex interactions among crop, soil, and landscapes in order to develop solutions that increase the efficiency and resilience of farming while decreasing farming's deleterious environmental impacts and protecting the Nation's irreplaceable soil resource. Joined ARS in April 1983.

***Kevin Jensen, Agricultural Science Research Technician***. Implements and completes multi-step projects investigating air and soil quality issues associated with complex agricultural systems. Joined NLAE in October 2006.

***Scott Johnson, Safety and Occupational Health Specialist***. Provides coordination and guidance in safety for the National Laboratory for Agriculture and the Environment, Corn Insects and Crop Genetics Research Unit and Plant Introduction Research Unit located on the Iowa State University campus. Joined ARS at the NCAH in 2010 as the Safety Compliance Officer in Facilities Engineering Unit and transferred to NLAE in December 2017.

***Douglas L. Karlen, Soil Scientist***. Responsible for developing, conducting, and reporting research results focused on using soil quality/health assessment to quantify physical, chemical, and biological effects of various soil and crop management practices, including tillage, crop rotation, nutrient management, manure management and crop residue harvest for biofuel and bio-product feedstock production. Joined ARS in December 1978.

***Tom Kaspar, Plant Physiologist***. Works on cover crops for corn and soybean rotations in the upper Midwest. Most of my work has been with winter rye cover crops in no till systems. Joined ARS in December 1981 and retired from ARS in December 2017.

***Brian Kerr, Animal Scientist***. To understand animal production systems and how feedstuffs (nutrient inputs) can be fed to maintain or improve animal performance. Within this mission, understanding gastrointestinal digestive function and integrity, whole animal health (immune function, oxidative stress, etc.) and their impact on nutrient and energy utilization is critical. This is all conducted to maximize nutrient utilization in the animal while minimizing nutrient excretion and the emission of gases into the environment, all in a sustainable and economic manner. Joined NLAE in January 2001.

***Erica Kistner, Ecologist.*** Examines how current conditions and future climate projections influence the distribution and abundance of key agricultural pests, pathogens, and weeds. The ultimate goal is to inform on pest management in a changing climate. To date, her modeling work has assessed how climate change may affect the negative impacts that the invasive brown marmorated stink bug and the superweed, Palmer amaranth, have on Midwestern agriculture. Joined ARS in 2016.

***Ben Knutson, Agricultural Science Technician.*** Research Farm Manager for NLAE actively supporting small plot field research activities and the maintenance and/or modification of research farm equipment. Joined NLAE in January 2000.

***Keith Kohler, Agricultural Science Technician***. Coordinates and implements field research settings within NLAE's Agroecosystem Management Research Unit. Provides agronomic insight, plot design, and data analysis. Routinely supplies field plot management expertise, and contributes daily in-season logistical support for all NLAE field experiments. Joined NLAE in January 1994.

***John Kovar, Soil Scientist***. Serves as Lead Scientist for the project "Cropping Systems for Enhanced Sustainability and Environmental Quality in the Upper Midwest", and for the NLAE's soil phosphorus (P) research associated with project plans in National Program 216 (Agricultural System Competitiveness and Sustainability. Joined NLAE in December 1999.

***Sally Logsdon, Soil Scientist***. Conducts soil physics and environmental quality research with a goal to determine how long-term rotations or perennial farming systems affect soil and water quality and seasonal (and off season) crop water use compared with conventional corn-soybean rotation. Joined ARS in November 1987.

***Evan Maifeld, Custodian***. Clean, maintain, and make minor repairs to the NLAE building. Joined NLAE in January 2014.

***Rob Malone, Agricultural Engineer.*** Integrating agricultural systems modeling with field data for investigating conservation and management practice effectiveness. Joined NLAE in April 2001.

***Melanie Moore, Program Support Assistant***. Member of the NLAE Administrative Team, assigned to the Soil, Water, and Air Resources Unit, providing support and assistance in all areas of administration, including travel, budget, personnel, and agreements. Joined NLAE in March 2001.

***Tom Moorman, Microbiologist***. Working to determine the spread of antibiotics and antibiotic-resistant bacteria in the environment after land application of manure from antibiotic-treated animals. Also investigates the distribution and activity of denitrifying bacteria in woodchip bioreactors that remove nitrate from tile drainage water. He is a co-leader of the Upper Mississippi River Basin LTAR (Long-Term Agroecosystem Research Network), which includes state and university scientists in Iowa, Minnesota, and Wisconsin. Joined ARS in September 1983.

***Amy Morrow, Chemist***. Responsible for the management and quality control of the analytical service laboratory, as well as the operation of an LC-MS for the detection of pharmaceuticals in the environment. Joined NLAE in May 1992.

***Jeff Nichols, Agricultural Science Technician***. Responsible for deployment, operation, and maintenance of hydrological and meteorological equipment; collection of data, samples, and field measurements; and coordination of field activities. Joined NLAE in March 1999.

***John Obrycki, ORISE Post-Doctoral Research Associate.*** Responsible for contributing to the selection of Landscape Design sampling sites; analyzing, interpreting, and preparing peer-review journal submissions associated with soil health/soil quality, profile soil nutrient assessments, and landscape management for sustainable bioenergy and bio-product production. Joined ARS in September 2016.

***Wolf Oesterreich, Biological Science Technician***. Set up field studies and then collects, processes, and analyzes reflectance data from various crop canopies. Supervises 8-12 student employees in the collection and processing of plant samples from hand-harvest events throughout the growing season. Joined ARS in September 1978.

***Jody Ohmacht, Agricultural Science Technician***. Manages the Cambardella lab and involved in aspects of the project: sample collection, initial processing, analyses preparation, and summary of data for transfer to Dr. Cambardella. Joined ARS in December 1987.

***Dan Olk, Soil Scientist***. Investigates the roles of individual amino acids, carbohydrates, and phenols in soil carbon sequestration, nutrient cycling, and turnover of young carbon fractions as affected by tillage, crop rotation and cover cropping. My field research group (Dana Dinnes plus student helpers and industry collaborators) determines the field efficacy of commercial humic products in promoting crop shoot and root growth and economic yield for corn and soybean under varying annual weather patterns and on different soil types. Recently begun work addresses underlying plant physiological processes. Joined NLAE in February 2001.

***Tim Parkin, Microbiologist.*** Focuses on greenhouse gas emissions (nitrous oxide, carbon dioxide, methane) from agricultural soils. Part of this research includes long term monitoring of emissions from corn/soybean systems as part of the USDA-ARS multi-location GRACEnet project. In addition, Dr. Parkin investigates mechanistic controls (e.g., soil water, temperature, nitrogen status, carbon availability) on greenhouse gas production and consumption by soil microorganisms. Joined ARS in January 1983.

***Larry Pellack, Biological Science Technician***. Technical support responsible for supporting field and laboratory aspects of the NLAE soil health/soil quality and sustainable bioenergy feedstock research program; point of contact for the ARS REAP and GRACEnet database development; and sample collection for the Landscape Design project. Joined ARS in December 1984.

***Sarah Porter, Physical Science Technician.*** Obtain and analyze high resolution geospatial data for use in precision conservation planning in agricultural watersheds. I have developed custom tools to enable this planning to occur locally across much of the Corn Belt. Joined NLAE in April 2012.

***John Prueger, Soil Scientist.*** A Research Micrometeorologist with responsibility to: (1) develop new cross-disciplinary knowledge and technology to understand impacts of current agricultural practices on environmental quality; (2) measure and model the impact of agricultural systems on greenhouse gas emissions; and (3) develop and evaluate potential mitigation strategies that enhance resiliency of agricultural production to climate change. Joined NLAE in May 1991.

***Patrick Quance, Facilities Operation Specialist***. Operates buildings environmental controls and utility systems to ensure occupant comfort. Performs routine preventive maintenance on building systems. Responds to occupant concerns in a timely and friendly manner. Lives by the motto “Do right and feed everyone”, and strives to keep Dr. Hatfield’s employees happy. Joined ARS in 2007 at NCAH, joined NLAE in 2017.

***Gary Radke***, ***Biological Science Technician*** **(TERM).** Responsible for collecting, preparing, and analyzing soil and plant samples associated with the NLAE soil health/soil quality and sustainable bioenergy feedstock research program; takes, interprets, and maintains photographic records of crop residue cover in response to tillage, stover harvest, and cover crop treatments. Joined NLAE in January 2011.

***Tom Sauer, Soil Scientist***. My role at NLAE is to conduct research at the interface of soil science and ecology, where I explore how changes in agricultural management, climate, and land-use impact soil and water quality by improving our understanding of the interrelationships among plant roots, soil organic matter, soil structure and the cycling of C and N in natural and managed ecosystems. Joined NLAE in August 1999.

***Kenwood Scoggin, Physical Science Technician***. Spectroscopist tasked with developing analytical methods for the assessment of agricultural environmental air quality impacts. Joined NLAE in January 1992.

***Martin Shipitalo, Soil Scientist***. My interests center on evaluating the field-scale effects of conservation tillage on soil and water quality with an emphasis on the role of macropores and earthworms. Currently, his research is focused on devising and testing practices to reduce the impact of the tile line surface inlets on water quality. Additionally, I am investigating the effects of corn stover harvest and cover crops on the amount and quality of surface runoff. Joined ARS in October 1986.

***Gavin Simmons, Biological Science Technician***. Builds and use devices (rainfall simulator, tall remote camera stand) to support laboratory and field research on long-term rotations and organic systems. Joined NLAE in May 1991.

***Otis Smith, Biological Science Technician.*** Trace gas testing in corn/soybean rotation field, for CO2/N2O/CH4. Analyze utilizing GC and order supplies as needed. Joined ARS in April 1991.

***Shari Steadham, Biological Science Technician***. Analysis of environmental and biological samples. Performs molecular biological techniques and technical laboratory support. Joined NLAE in October 2005.

***Isaac Svoboda, Biological Science Aid.*** Assists with sample collection and preparation for soil and water analyses, inventory and culture maintenance. Joined NLAE in August 2017.

***Bert Swalla, Agricultural Science Technician***. Collects samples and preps, process, analyzes, and summarizes samples. Joined NLAE in December 1989.

***Cynthia Swalla, Physical Science Technician* (TERM).** Implements physical, chemical, and instrumental procedures to accomplish specified research objectives. Joined NLAE in September 2010.

***Emily Syverson, Receptionist (Term).*** Provides receptionist support for the laboratory, greets visitors, responsible for incoming and outgoing shipments.

***Dennis Todey, Director, Midwest Climate Hub***. He has a long record of working in ag-climate services across the Midwest and Northern Plains as the state climatologist for South Dakota and working with various partners. He leads the Midwest Climate Hub in developing partnerships across the region on developing new information and sharing, and improved use of existing information. Joined ARS in 2016.

***Mark Tomer, Soil Scientist***. Lead Scientist for NLAE's water quality project; with his training in soil science and hydrology, he conducts research to develop GIS-based watershed planning tools and to assess watersheds, water quality, and the effectiveness of conservation practices. Joined NLAE in September 2000.

***Steve Trabue, Chemist***. Characterizing and quantifying the release and environmental fate of organic products from agricultural operations. Joined NLAE in October 2001.

***Jessica Van Horn, Physical Science Technician, GIS Specialist.*** Applies GIS technology to agricultural and ecological applications to support the development and transfer of information on the Agricultural Conservation Planning Framework (ACPF) tool. Joined NLAE in 2016.

***Kenneth Wacha, Soil Scientist (ORISE Post-doc).*** Responsible for research on the changes in soil aggregates and soil properties under changing management conditions. Quantifies the spatial variation of soil within fields as affected by management. Joined NLAE in 2017.

***Tim Watts, Physical Science Technician.*** Providing analytical services focusing on carbon and nitrogen analysis for plants and soils, nitrate analysis in water and soils, and herbicide analysis in water and soils. Joined NLAE in September 1991.

***Riley Wilgenbusch, Biological Science Aid.*** Assists part-time with routine processing of soil plant samples and washes glassware. Joined NLAE in 2017.

***Anthony Williams, Biological Research Technician***. Contributes to all research phases of field evaluations for commercial humic products. Performs laboratory analyses for plant structural biochemistry and soil physical properties, and measures yield components for corn and soybean. Contributes to the collection of plant and soil samples from the field experiments for leaf area, plant hormones, plant biochemistry, plant nutrient uptake, grain yield, and yield components. Joined NLAE in 2014.

***Kellie Winter, Biological Science Technician***. Provides laboratory and analytical support for investigation of *Salmonella* colonization and pathogenesis in food-producing animals and the evaluation of alternatives to antibiotics. Joined NLAE in March 2005.

## *Previous NLAE Employees*

| | | |
|---|---|---|
| Anissa Ameen | Colin Greenan | Becky Roland |
| Kevin Anderson | Tim Hart | Aaron Rosales |
| Susan Andrews | Rich Hartwig | Donna Schmitz |
| Jennifer Anhalt | Mike Howard | Judy Shoen |
| Todd Atherly | Vicki Jones | Jeremy Singer |
| Ed Berry | Larry Kramer | Tom Steinheimer |
| Shawn Blaesing-Thompson | David Laird | Pam Stewart |
| Jennifer Boeckmann | Kevin Loeffelmann | Bill Stotts |
| Robert Braun | Dean Martens | Mike Sukup |
| Doug Buhler | Terry Meade | Bill Tharrington |
| Mike Burkart | David Meek | Don Timmons |
| Dan Burke | Lisa Mens | Nader Vakili |
| Tom Colvin | Troy Murphy | Tom Weber |
| Diane Cronk | Nancy Nubel | Jaci Weese |
| John Crouse | Jim Peterson | Rachael Whitehair |
| Paul Doi | Caroline Peterson | Eva Wojcik |
| Don Erbach | Richard Pfeiffer | Jim Zahn |
| Scott Farris | Jerry Radke | Cherie Ziemer |
| Pierce Fleming | | |