**Purdue Extension**
**2018 Annual Accomplishment Report to USDA NIFA**
**Impact Statements by Planned Program**

The Purdue Extension and Research outcomes and impact statements are organized into these seven Planned Programs:

- Childhood Obesity
- Climate Change
- Food Safety
- Global Food Security and Hunger
- Human, Family, and Community, Health and Well-being
- Natural Resources and the Environment
- Sustainable Energy

Outcomes provide the metrics that our Educators and Specialists report across research and Extension program efforts. The impact statements shared highlight a program or project addressing the outcomes and provide narrative on the issue, what has been done, and the results. There are impact statements for research projects, for Extension programs, and for integrated research and Extension activities.

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# *Climate Change*

Title
Trace gas emissions from landscapes and agricultural operations

Research
Richard Grant, Agronomy

Outcome
2 - CC 1.6 - # New assessment and management tools developed, including models and measurements of greenhouse gas emissions

Issue
It is estimated that agriculture is responsible for 6% of total U.S. greenhouse gas emissions: primarily from methane ($CH_4$) and nitrous oxide ($N_2O$) (USEPA, 2014). The largest single source of $CH_4$ is enteric fermentation (USEPA, 2014). Fertilizer application and other cropping practices account for 68% of estimated emissions of $N_2O$. $CO_2$ emissions from land surface and agricultural operations must be evaluated to understand carbon cycling (Riveros-Iregui and McGlynn, 2009). Among three greenhouse gases (GHG), the Intergovernmental Panel on Climate Change (IPCC, 2001) specified methods for nations to estimate the GHG emissions of each sector of the economy (IPCC, 1997), which is to multiply an activity (for example, tons of manure applied to cropland) by an associated emission factor (Kebreab et al 2006). While $NH_3$ is not a GHG, it is considered to be a secondary GHG because $N_2O$ is often produced through oxidation of $NH_3$. Livestock management and fertilizer application contributed about 85% of total ammonia emissions in 1998 (USEPA, 2002). The USEPA inventory indicated typical N losses as $NH_3$ of 38% for dairies and 63% for swine operations (USEPA, 2004). Recently emissions estimation methods for livestock operations and land surfaces at farm-scale have been promulgated by the USDA (Eve et al, 2014), but there remain significant gaps in our ability to estimate GHG and $NH_3$ emissions.

What has been done
This study evaluates emissions from many agricultural operations where little is known, such as $N_2O$ and $NH_3$ emissions from fields with applied manure or inorganic fertilizer and $CO_2$ and $CH_4$ emissions from pastureland. Project objectives are: 1) Develop methodologies to measure $NH_3$, $CO_2$, $CH_4$, and $N_2O$ emissions from landscapes and fugitive sources including agricultural and natural gas production operations. 2) Measure $NH_3$, $CO_2$, $CH_4$, and $N_2O$ emissions from

cropping and livestock agricultural operations spanning a range of management practices and geographic/ climatological zones. 3) Determine the effect of animal type and management regime on livestock greenhouse gas (GHG) emissions and the effect of crop and soil type, and weather on cropped-land GHG emissions.

Results

Measurements of NH3 were made in June 2018 using open-path tunable diode laser (TDL) NH3 concentrations across a single fertilized field for a total of 272 half-hour periods. Measurements of N2O emissions were made between May and July 2018 using cavity ring-down laser N2O concentration measurements of line-sampled air collected around the edge of two adjacent fertilized fields for a total of 1692 half-hour periods. Measurements are being completed as part of a proof-of-concept of high-throughput processing of the diverse set of measurements (Internet of things) using edge-of-cloud preprocessing and a parallel stream transformational loader in combination with high performance computing of the final emissions. Swine waste storage is a major source of agricultural NH3 emissions. Hog manure is stored in slurry pits, tanks, or lagoons. Ammonia emissions from a ground-level midwestern hog finisher manure tank collecting manure from a mean of 3508 animals was measured for 8 to 20 days each quarter of the year for two years. Emissions from the tank were greater on an area basis but comparable on an animal basis relative to emissions from much larger anaerobic lagoons. Emissions were correlated with air temperature and manure composition, but not wind speed or friction velocity, probably due to the turbulence created by the tank structure under all winds. Crusting of the manure surface in the tank corresponded with a non-significant 10% increase in NH3 emissions. Manure on dairies is the second largest agricultural source of NH3 emissions. Ongoing analyses of ammonia emissions at a western open-lot dairy were conducted. Ammonia concentrations measured by TDL concentration measurements and turbulence by sonic anemometers were analyzed. Both 30-minute and daily average emissions were influenced by air temperature. Emissions were also linearly related to wind speed. A distinct daily pattern in NH3 emissions was consistent with daily patterns in both wind speed and air temperature. The mean daytime emissions were twice the mean nighttime emissions. Daily emissions varied over the year with summer emissions twice that of winter. Annual emission for the farm was estimated with summer emissions twice that of the fall and winter. Additional studies are needed to evaluate the frequency of high emission days during the summer.

Title

A regional-scale study of invasive plant impacts on forest ecosystem

Research

Songlin Fei, Forestry and Natural Resources

Outcome

24 - CC 1.8 - # New climate relevant databases, monitoring systems, and inventories managed or under development

Issue

The Central Hardwood Forest is one of the most important forest ecosystems in the eastern U.S., harboring high diversity of native species and providing valuable economic and recreational opportunities to the citizens of the region. With ongoing fragmentation, new fire regimes, modern land-use and forest management practices, and other factors, invasive exotic plants are moving into these economically and ecologically important forest ecosystems, in some places reaching epidemic proportions. The health and longevity of these forest ecosystems are at risk. Long-term invasion of exotic plants can alter composition and reduce diversity of these ecosystems, especially those mast-bearing, fire mediated oak and hickory species. Such a compositional change could result in dramatic declines in wildlife population and diminished economic opportunities for the human inhabitants of these largely rural regions. Moreover, forests play an important role in U.S. economy. In the Central Hardwood Forest region alone, over 255,000 individuals are employed in forestry-related jobs (AFPA 2012). On the other hand, invasive species cost the American public about $1,300 per household each year based on an earlier estimation (Pimentel et al. 2005). Therefore, research on the impact of invasive species on forest health and strategies in order to remediate the impact will have huge economic implications.

What has been done

The overarching goal is to understand impacts of invasive plants on forest ecosystem dynamics at the regional level by including spatial heterogeneity and system stochasticity. Understanding biodiversity-productivity relationships (BPRs) is

of theoretical importance, and has important management implications. Most work on BPRs has focused on simple and/or experimentally assembled communities, and it is unclear how these observed BPRs can be extended to complex natural forest ecosystems. Research objectives are: 1) Evaluate the extent and severity of invasive plants impact on tree growth, mortality, and recruitment. 2) Understand the impact of plant invasions on soil organic carbon pools and temperature sensitivity. Researchers analyzed U.S. Forest Inventory and plant data from 2012-16 including species composition, diameter, height, age, and other attributes from more than 115,000 forest plots from the 48 contiguous states.

Results
Findings, reported in the journal Nature Communications (https://www.nature.com/articles/s41467-018-07880-w), reveal that relationships between biodiversity and forest productivity depend strongly on climate. Researchers demonstrated there is a positive biodiversity-productivity relationship in dry, especially warm climates. Forests in dry, warm climates show a positive linear relationship between biodiversity and productivity, meaning the forest becomes increasingly productive as more species are introduced. As humidity rises, the relationship changes and productivity rises and then declines as species richness increases. But in areas that are humid, the relationship between biodiversity and productivity curves. Biodiversity and productivity increase together until a point at which more species begin to cause productivity declines. The findings are important for management, restoration and conservation of forests, many of which provide important ecosystem services but are threatened by deforestation, climate change and invasive species. Climate change needs to be considered when making these management decisions. A cool, wet forest today could look much different in the coming decades. Climate change is going to push these forests into a different climate zone, potentially changing the biodiversity-productivity relationship. Climatic variation is an underlying determinant of contrasting BPRs observed across a large spatial extent, while both biotic factors (e.g., stand age and density) and abiotic factors (e.g., soil properties) can impact BPRs within a given climate unit. These findings suggest that tradeoffs need to be made when considering whether to maximize productivity versus conserve biodiversity.

Title
Cover crop and drainage management systems impacts on crop production, soil health, N cycling and water quality

Research
Shalamar Armstrong, Agronomy

Outcome
1 - GFSH 2.13 - # of projects related to managing impacts from large-scale operations: non-point source pollution, water use & allocation, watershed impacts, model development

Issue
Within the Upper Mississippi River Basin, the autonomy of farmers in making nutrient management decisions for their row crop agricultural fields continues to be threatened due to the loss of nitrate via tile drainage that contributes to impairments in the Gulf of Mexico and local drinking water sources. Nutrient loading the Gulf of Mexico from tile-drained agricultural land continues to be an environmental issue that threatens the sustainability of row crop agriculture. In the future, farmers may be required to comply with federal regulations concerning surface and subsurface runoff leaving their fields. Whether specific conservation practices remain voluntary or become mandated in the Midwest, data from this research program will be a source of information for farmers to use to make critical management decisions. Strategies are needed to better enable subsurface tile drainage to perform its critical function in removing excess water in spring, while reducing the unwanted loss of nitrate in the drainage waters.

What has been done
This program identifies and investigates adaptive agriculture management practices that improve sustainability and resilience of cropping and nitrogen management systems to climate variation through increased soil health, water quality, and crop production. Understanding cover crop impacts on N availability and rate and soil health are vital in increasing cover crop adoption, reducing nitrate loading, and maintaining sustained profitable yield in the Upper Mississippi River basin. Project investigations are: 1) ability of cover crops to conserve N within corn and soybean cropping systems and reduce nitrate loading via tile drainage; 2) decomposition of cover crop residue after termination

and the synchronization of cover crop N release with cash crop N demand; 3) cash crop utilization of N release from cover crop residue; 4) impact of cover crops on the diversity of the soil microbiome over time; and 5) impacts of cover crops on soil health and crop production. Soil samples were taken to characterize long-term changes in properties from subsurface drainage installation 35 years ago. Long-term tile drainage/water quality studies at Southeast Purdue Agriculture Center had drainage tiles installed at 5, 10, 20, and 40 m spacing in 1983, and changes in flow characteristics have been observed over time. Samples were taken at multiple depths and distances from the drains, to characterize bulk density, water retention, aggregate stability, carbon, nitrogen, and penetration resistance. Samples are being analyzed. Cover crop studies were continued at three Purdue research centers and 14 farmer cooperator sites, in collaboration with the Conservation Cropping Systems Initiative (CCSI) and other conservation partners in Indiana. A final soil health sampling occurred in summer 2018, to evaluate changes in soil health over a 5-year period from the baseline sampling in 2013. Individual farmer reports were prepared for each site through the 2016 sampling, and a report of the more limited 2017 data was prepared. These reports are available on CCSI website: http://ccsin.iaswcd.org/.

Results

Findings quantified the impact of different N management timings and the inclusion of cover crops on nitrate-nitrogen loading and determined that cover crops had the ability to significantly reduce the loss of nitrate-nitrogen from a tile-drained field despite the nitrogen application timing. Cover crops reduced the leaching of dissolved reactive phosphorus. A major accomplishment was characterizing the dynamic and extent of soil bacteria microbiome response to inclusion of different cover crop species. The soil microbiome is the driver of nitrogen availability, thus understanding its response to cover crop adoption will help inform farmers to alter nitrogen fertilizer management following adoption of cover crops for optimum production. Another significant accomplishment was the development of methodology allowing cover crop adopting farmers the ability to perform in-season cover crop stand surveys of biomass and nitrogen uptake with only limited field sampling. This in-season survey is critical because it informs the cover crop management (termination) and cash crop management (nitrogen application timing and rate and residue management setting on the planter). Other findings quantified the synchrony of cover crop carbon and nitrogen release with corn and soybean critical nitrogen demanding growth stages. Quantified actual nitrogen uptake by corn and soybean planted subsequent to a cereal cover crop. This accomplishment is critical because it will help educate farmers and associated community on what percentage of N from the cover crop residue is used by the following cash crop, which could lead to adaptive management. Significant advances were made toward determining short-term economic benefit and risk of cover crop adoption. Data generated from these studies have the potential to help farmers better understand how cover crops interact with fertilizer and soil inorganic N, the relationship between cover crop species, termination timing and N release from cover crop residue in the cash crop growing season, the availability of N from cover crop residue, and the range of improvements in soil health that can be expected from cover crops.

Title

Assessing and improving sustainability of confined animal feeding operations

Research

Al Heber, Agricultural and Biological Engineering

Outcome

25 - FME 2.1 - # of discoveries, innovations, technologies and technology transfer related to performance management of farms

Issue

In livestock industries, the primary objective is efficient production of high quality, nutritious and wholesome meat, egg and dairy products for health-conscious consumers at reasonable cost. In addition, accumulation of N and P in soils and the threat to quality of surface water are major livestock production sustainability issues. The need is great to minimize the flow of detrimental levels of dietary nutrients through animal manure for an environmentally-sustainable animal production practice. Therefore, the efficiency of dietary nutrient utilization to minimize the flow of detrimental levels of dietary nutrients through animal manure to the environment is an important research goal. Understanding the role of manure storage, treatment and application with respect to nutrients and GHG dynamics across air-soil-water interfaces

and its impacts on local microbial function is expected to lead to substantial improvements in managing manure application and predicting its environmental impacts. Effective manure treatment and methods of application can have significant impact on N and P cycling, and gas emissions in agriculture and ecosystems.

What has been done

Research goals are: 1) determine the influence of exogenous enzymes and modified feed ingredients on ileal and total tract digestibility of N and P, and nutrient excretion and gaseous emissions. 2) Evaluate effects of diet on health status and environmental footprint of swine and broiler production. 3) Reduce impact of odor, particulate matter, and noxious gases emitted from confined animal facilities. 4) Improve understanding of the impacts of manure storage, treatment, and land-application on N, P, and greenhouse gas transformations and losses across air-soil-water interfaces.

Results

Thirty-two barrows were used in a 35 day experiment to evaluate effects of supplemental soluble fiber (dextrin) pre- and post-weaning on growth performance and volatile fatty acids (VFA) production. Fiber was suspended in chocolate milk and administered orally through a syringe from 14 days prior to weaning until 4 days post-weaning, after which it was included in the diet at 1%. At weaning, pigs were group housed by treatment and allowed ad libitum access to a common starter diet. On day 4 post-weaning, pigs were moved to individual pens and fed diets with or without 1% fiber. Weights and feed intake were recorded 14 and 3 days prior to weaning, and on day 0, 4, 11, and 21 post-weaning. On day 21 post-weaning, pigs were euthanized, and large intestine contents were collected for VFA analysis. Growth performance was not affected by treatment. A trend for an interaction of pre- and post-weaning fiber supplementation was observed for acetate and butyrate concentrations in large intestine contents. Pigs fed fiber only in the nursey had the highest acetate concentration, while pigs never receiving fiber had the lowest concentration. Pre-weaning fiber supplementation followed by no fiber in the nursery resulted in the highest butyrate concentrations with all other treatments being similar. Fiber supplementation pre-weaning tended to reduce isobutyrate concentrations. Pigs not receiving fiber post-weaning had increased valerate concentrations. Fiber supplementation caused alterations in VFA concentrations when fed during pre- and post-weaning, indicating possible shifts in the microbiome, immune status and barrier function of the intestinal tract. Researchers completed: 1) diet manipulation and air quality in an experimental swine building, and 2) effects of dairy manure anaerobic treatment on nutrient flow in the environment. A model to predict thermal environment inside sow gestation barns was completed. Model inputs are weather, building orientation, dimensions and materials, geographical location, and sow herd characteristics, and outputs are daily means of inside temperatures and ventilation rates, and annual costs of electricity and supplement heat. The model showed that total energy costs are influenced significantly by temperature set point, thickness of ceiling insulation, and minimum ventilation rate. For an indoor recirculation aquaculture systems study, 3 Tilapia and 2 shrimp buildings were surveyed in winter and summer, and temperatures were recorded for at least 2 weeks. Recommendations were made to remedy observed inadequate ventilation rates and air distribution, excessive surface condensation, excessive heat loss, improper attic ventilation, inadequately sized heat exchangers, ill-advised use of expensive dehumidifiers, improper vapor barrier installation, and ill-advised use of ceiling inlets. A spreadsheet model was developed to calculate building heat loss factors and heat and moisture balances, predict surface condensation, determine proper ventilation rates, and estimate energy usage. Calculations showed ventilation is more efficient for removing humidity than dehumidification, and uninsulated floors are responsible for a significant amount of building heat loss. Results and conclusions from these studies can provide supporting information to assist research-based decision making and lead to more eco-friendly manure management practices, which will effectively reduce environmental pollution from agriculture and preserve a sustainable environment.