

V(A). Planned Program (Summary)

Program # 1

1. Name of the Planned Program

Agricultural And Biological Engineering

Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
112	Watershed Protection and Management	20%		15%	
133	Pollution Prevention and Mitigation	5%		10%	
141	Air Resource Protection and Management	35%		10%	
401	Structures, Facilities, and General Purpose Farm Supplies	10%		15%	
402	Engineering Systems and Equipment	15%		25%	
403	Waste Disposal, Recycling, and Reuse	5%		5%	
404	Instrumentation and Control Systems	0%		10%	
405	Drainage and Irrigation Systems and Facilities	10%		10%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2013	Extension		Research	
	1862	1890	1862	1890
Plan	1.0	0.0	3.0	0.0
Actual Paid Professional	0.0	0.0	4.7	0.0
Actual Volunteer	0.0	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
12205	0	314296	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
12205	0	314296	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
64027	0	1066437	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Activities in 2013 included ongoing characterization of plots for the purpose of DSSAT calibration [**Decision Support System for Agrotechnology Transfer** is a software application program that comprises crop simulation models for over 28 crops], the monitoring of bioaerosol concentrations at the air exhaust of CAFOs with the ultimate goal of developing cost-effective control strategies to reduce bioaerosol emissions, efforts to improve the efficiency of liquid agricultural chemical application systems, the development of a set of specifications, schematics and devices for interfacing biosensors with portable computers including modern smartphones, efforts to increase our knowledge base with regard to hydrothermal liquefaction and direct pyrolysis of specific high-impact agricultural residuals as well as for algae [which we are using to recycle waste nutrients from agricultural residuals into useful products], testing of drift reduction nozzles and adjuvants for use on Dicamba applications, work to improve our understanding of the intrinsic structural, chemical and biological changes in corn kernels and soybean seeds during storage and processing [this will lead to a better predictions of the nutritional value of delivered corn and soybeans and new food processing techniques to increase bioavailability and stability of micronutrients in fortified foods], further development of the **Illinois Manure Management Plan** planning and recordkeeping tools and the IMMP website [www.immp.uiuc.edu], the development of a machine for mechanical weeding for corn, new crop-based guidance mechanisms for our agricultural robot, several novel techniques to measure the yield of energy crops based on machine vision, and the improvement of techniques for low-cost micro-environment monitoring and control [these allow users to estimate how much water to use during mist or fogging in plant-propagating settings].

Conference presentations included the American Society of Agricultural and Biological Engineers, American Society of Chemistry, American Society of Chemical Engineers, Illinois Pork Expo, and Certified Livestock Manager Training workshops.

Extension activities related to this planned program are interdisciplinary in nature and relate to other planned programs featured in this report [such as Sustainable Energy, Natural Resources and the Environment, and Animal Health & Production]. Much effort was devoted to education focusing on livestock manure management through eight statewide **Certified Livestock Manager Training** workshops and an online five-part quiz series, both of which meet state livestock waste management training requirements for producers. Livestock producers with 300 or more animal units must be recertified through training and/or satisfactory performance on an examination every three years.

With limited Extension specialist FTE's, Extension has chosen to expand outreach through websites. The **Manure Central** website [www.immp.uiuc.edu] experienced over 150,000 web page views this past year and consists of several sections that include: [1] **Certified Livestock Management Training**

materials and the **Illinois Manure Management Plan** designed to help livestock producers in developing manure management plans that result in safer and more efficient use of manure. The website allows customization of the plan to meet a given producer's needs and facilitates any required annual updates. [2] **Manure Share**, an exchange program that brings gardeners and landscapers searching for organic materials for use in composting or field applications in contact with livestock owners with excess manure. [3] The **Small Farms Manure Management** website for individuals with less than 300 animal units [4,000+ page views]. [4] **EZregs** for users who have established accounts to store their questions and Extension responses related to identifying environmental regulations that pertain to specific agricultural and horticultural operations and practices in Illinois. [5] **Compost Central** which features resources for composting of livestock manure, food scraps, and yard waste. Training was also provided for custom manure haulers in Illinois, providing certification and testing on a voluntary basis.

Two online modules for certified crop advisers on how tiling can be used to control water table levels and use of bioreactors to reduce nutrient loading into surface water were completed this year. With respect to education regarding equipment, **Operation S.A.F.E. Fly-in** was conducted in Illinois as well as other states by an Extension pesticide safety education staff member to ensure aerial applications of fungicides to corn are accurately applied and encompassed information related to spraying equipment. The **Corn and Soybean Classics** series included a presentation by an agricultural engineering Extension specialist on calibrating sprayer quality requirements for pesticide applicators. Extension faculty and staff with agricultural engineering expertise have also provided leadership in programming that addresses sustainable energy [see Sustainable Energy planned program] and soil drainage research findings [see Natural Resources and the Environment planned program]. In addition, there were 44,000 page views on the **Agriculture Safety and Health** website.

This year's **2013 4-H National Youth Science Day: Maps and Apps** reached more than 3,500 youth ranging from elementary school through high school who participated in a set of activities that involved designing their ideal park and using GIS mapping to solve community problems and contribute data about their community to the United States Geological Survey.

2. Brief description of the target audience

Members of the target audience included agricultural engineers, environmental consultants, researchers in the livestock industry, animal scientists, livestock producers, students and researchers in the areas of biosensors and nanotechnology as applied to agriculture, the asphalt industry, the wastewater treatment industry, aerial applicators, commercial ground rig applicators, private ground rig applicators, pesticide adjuvant manufacturers, pesticide registrants, custom manure haulers, state and federal regulatory agency representatives, livestock commodity group representatives, Extension field staff and educators, and the horticultural research community. In addition, Extension audiences included crop producers, certified crop advisers, gardeners, landscapers, and youth.

3. How was eXtension used?

eXtension was not used in this program

V(E). Planned Program (Outputs)

1. Standard output measures

2013	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	726	2672	1867	0

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year: 2013

Actual: 2

Patents listed

TF 12087-PRO2 [Particle Tracking System] and TF 12087-US [Particle Tracking System and Method].

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2013	Extension	Research	Total
Actual	0	37	37

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number Of Completed Hatch Projects

Year	Actual
2013	4

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Number Of Subsurface Bioreactor Acres In Illinois
2	Producer Reported Changes/Improvement In Manure Management And Application Method To Reduce Odor
3	Producer Reported Knowledge Changes Related To Manure Management
4	Developing Cost-Effective Control Strategies To Reduce Bioaerosol Emissions
5	Turning The Residual Waste Products That Currently Cause Significant GHG Emissions Into A Carbon Sink
6	Maximizing Efficiency And Minimizing Drift For Agricultural Aerial Applications
7	Improving Emission Control Technologies For Livestock Buildings
8	Development And Use Of A Manure Management Plan

Outcome #1

1. Outcome Measures

Number Of Subsurface Bioreactor Acres In Illinois

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Nutrient runoff from agricultural fields into water bodies is of particular concern in the Midwest, where increased nitrate leaching into the Mississippi River has been identified as a major contributor to growing hypoxia in the Gulf of Mexico. There is a strong correlation between improved drainage and elevated nutrient transport from cropped land. Scientists recommend implementing a variety of practices that lead to a reduction of both nitrogen and phosphorus fluxes.

What has been done

To reduce nutrient loading from subsurface drained fields, we have been developing and promoting the use of fixed-bed, in-field subsurface bioreactors. A subsurface bioreactor is a buried trench with woodchips [or some other carbon source] through which the tile water flows before entering a surface water body. Organisms from the soil colonize the woodchips. Some of them break down the woodchips into smaller organic particles. Other microorganisms use the carbon produced by the woodchips as an energy source and reduce nitrate to nitrogen gas, which exits the bioreactor into the atmosphere. Through this mechanism, nitrate is removed from the tile water before it can enter surface waters. No new bioreactor acres were installed in Illinois in 2013. Rather, the Natural Resources Conservation Service has established a program for cost sharing on bioreactors and has held training sessions for field staff with program implementation scheduled for late 2014.

Results

We have proposed a protocol for the sizing of subsurface bioreactors and have developed an interactive routine in which this protocol has been implemented. We proposed that bioreactor sizing be based on 10-year, 24-hour peak monthly drain flow, and are developing a database of county-level soil, rainfall, and temperature information to determine these peak flows for states in the Midwest. The protocol has been adopted by the NRCS. This database is fully populated for

Illinois, Ohio, Indiana, North and South Dakota, Michigan, Minnesota, Iowa, Missouri, and Wisconsin.

4. Associated Knowledge Areas

KA Code	Knowledge Area
112	Watershed Protection and Management
133	Pollution Prevention and Mitigation
402	Engineering Systems and Equipment
403	Waste Disposal, Recycling, and Reuse
405	Drainage and Irrigation Systems and Facilities

Outcome #2

1. Outcome Measures

Producer Reported Changes/Improvement In Manure Management And Application Method To Reduce Odor

Not Reporting on this Outcome Measure

Outcome #3

1. Outcome Measures

Producer Reported Knowledge Changes Related To Manure Management

Not Reporting on this Outcome Measure

Outcome #4

1. Outcome Measures

Developing Cost-Effective Control Strategies To Reduce Bioaerosol Emissions

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Mitigation of bioaerosol emissions from concentrated animal feeding operations [CAFOs] demands knowledge of bioaerosol concentrations feeding into an end-of-pipe air treatment process. Monitoring bioaerosol concentrations at the air exhaust of CAFOs can offer essential information for developing cost-effective control strategies to reduce bioaerosol emissions. As two often selected indicators for bioaerosol contamination, airborne endotoxin and [1-3]-b-D-glucan are associated with the occurrence of atopy and acute and chronic respiratory symptoms, such as pulmonary inflammation, nonallergic asthma, airway obstruction, and decreased lung function. Endotoxin is a cellwall component of gram-negative bacteria. They are released when bacterial cells are lysed or at the multiplication stage.

What has been done

In this study, samples of total suspended particulate [TSP] at the air exhaust of swine and poultry CAFOs were collected to determine total endotoxin and [1-3]-b-D-glucan concentrations using kinetic chromogenic *Limulus amoebocyte lysate* [LAL] assays. The aim of this preliminary study was to measure total endotoxin and [1-3]-b-glucan concentrations at the air exhaust of 18 commercial CAFOs and to examine their variability with animal operation type [swine farrowing, swine gestation, swine weaning, swine finishing, manure belt laying hen, and tom turkey] and season [cold, mild, and hot]. The measured airborne concentrations of total endotoxin ranged from 98 to 23,157 endotoxin units [EU]/m³, and the airborne concentrations of total [1-3]-b-D-glucan ranged from 2.4 to 537.9 ng/m³. Animal operation type in this study had a significant effect on airborne concentrations of total endotoxin and [1-3]-b-D-glucan but no significant effect on their concentrations in total suspended particulate [TSP]. Both endotoxin and [1-3]-b-D-glucan attained their highest airborne concentrations in visited tom turkey buildings. Comparatively, season had no significant effect on airborne concentrations of total endotoxin or [1-3]-b-D-glucan. Endotoxin and [1-3]-b-glucan concentrations in TSP dust appeared to increase as the weather became warmer, and this seasonal effect was significant in swine buildings. Elevated indoor temperatures in the hot season were considered to facilitate the growth and propagation of bacteria and fungi, thus leading to higher biocomponent concentrations in TSP.

Results

These findings suggest that endotoxin and [1-3]-b-D-glucan may attain their maximum emission rates in summer. It is therefore recommended that particular attention should be paid to further investigating summertime bioaerosol emissions from animal feeding operations and the emissions' impact on neighboring communities.

4. Associated Knowledge Areas

KA Code	Knowledge Area
133	Pollution Prevention and Mitigation
141	Air Resource Protection and Management
401	Structures, Facilities, and General Purpose Farm Supplies
404	Instrumentation and Control Systems

Outcome #5

1. Outcome Measures

Turning The Residual Waste Products That Currently Cause Significant GHG Emissions Into A Carbon Sink

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

The objectives of this project are: [1] To demonstrate integrated algal production systems that treat agricultural residuals. We will investigate and optimize the performance of mixed-algal treatment systems that provide water quality improvements and new biomass feedstocks derived from agricultural residuals and atmospheric carbon. The carbon capturing capabilities and efficiencies will be determined during this process. [2] To investigate the mechanisms of hydrothermal liquefaction [HTL] processes to produce valuable products. Bench and pilot-scale reactors will be used to investigate the novel treatment systems and to develop and quantify key process performance criteria including feedstock recipe, operating conditions, reaction rates, water usage, water quality improvements, yield of valuable products, and greenhouse gas reductions that can be used for scale-up in industrial applications.

What has been done

In 2013, effort has been focused on developing a new laboratory that will integrate HTL-ABT at the University Swine Research Center. This new lab will provide a one-stop visit of crude oil production, algae growing, wastewater treatment, nutrient recycling and carbon capture.

Results

Through this project, we are introducing a potential paradigm shift in the climate change impacts of agricultural activities by turning the residual waste products that currently cause significant GHG emissions into a carbon sink sufficient in size to offset all the other emissions of the agricultural enterprise. We will significantly increase our knowledge base on hydrothermal liquefaction and direct pyrolysis of specific high-impact agricultural residuals as well as for algae, which we are using to recycle waste nutrients from agricultural residuals into useful products. As a result, we will also improve the knowledge base for culturing fast-growing algae in wastewater treatment situations and the cleaning of these wastewaters provided by the algae.

4. Associated Knowledge Areas

KA Code	Knowledge Area
112	Watershed Protection and Management
133	Pollution Prevention and Mitigation
141	Air Resource Protection and Management
402	Engineering Systems and Equipment
403	Waste Disposal, Recycling, and Reuse
405	Drainage and Irrigation Systems and Facilities

Outcome #6

1. Outcome Measures

Maximizing Efficiency And Minimizing Drift For Agricultural Aerial Applications

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

The primary objective of this project is to evaluate nozzle performance, both selection and usage, and with the inclusion of spray adjuvants. The goal will be to create recommendations for various application scenarios common to agriculture in Illinois, both aerial and ground, that maximize efficacy while minimizing drift.

What has been done

The following individual projects are being conducted to meet this objective: [1] Evaluation of various adjuvants for efficacy and drift control for low-volume aerial applications of fungicides on corn [adjuvants to be tested include deposition aids, surfactants, crop oils, and others]; [2] An investigation of how various pesticides and adjuvants impact the spray droplet size and pattern uniformity for aerial applications [pesticides will primarily be foliar fungicides commonly applied to corn in Illinois and adjuvants to be tested include deposition aids, surfactants, crop oils, and others]; [3] A study to determine how swath width, application height, and weather factors impact the uniformity of low-volume aerial applications on corn [the spray patterns will be measured using a monofilament line strung through a corn field at ear height]; [4] Measurement of the

differences in efficacy and drift reduction of various nozzle types used in aerial application; [5] Comparison of the efficacy of a low-volume aerial application and a high-volume ground application; [6] Determination of the impact the use of automatic spray rate controllers has on spray droplet spectrum and application uniformity [popular nozzle types and sizes will be examined at pressures throughout their pressure range to determine how the droplet size and pattern width changes and the pressure increases]; and [7] A study to determine the impact various pesticides, deposition aids, and surfactants have on the spray droplet spectrum of popular ground application nozzles.

Results

Testing of drift reduction nozzles and adjuvants for use on Dicamba applications was conducted on glyphosate-resistant waterhemp. Results confirmed past research that these tools can be successfully used. The project to evaluate swath width, application height, and how weather factors impact uniformity of applications of fungicide in corn was completed, as was the study to determine the impact of adjuvants on these applications.

4. Associated Knowledge Areas

KA Code	Knowledge Area
133	Pollution Prevention and Mitigation
141	Air Resource Protection and Management
401	Structures, Facilities, and General Purpose Farm Supplies
402	Engineering Systems and Equipment
404	Instrumentation and Control Systems

Outcome #7

1. Outcome Measures

Improving Emission Control Technologies For Livestock Buildings

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Biofilter packing materials and an innovative trickling biofilter were evaluated for their effectiveness in controlling ammonia emissions from swine buildings.

What has been done

A new style of biofilter container was designed, constructed and demonstrated on the University of Illinois livestock farm. Instrumentation was installed on the new biofilter to monitor ammonia removal and concentrations of other gases. A biofilter demonstration site was developed for swine producer training on how to design, construct, and manage biofilters for ventilation air cleaning. We conducted studies of various biofilter media, especially airflow characteristics linking particle size distribution, moisture content, and other factors. Ammonia removal of biofilters was studied in relation to moisture content of target organic media. We now have a much better understanding of the ammonia removal process as related to moisture content of organic media. We are better able to predict ammonia removal based on media moisture content and ammonia loading history. We have an improved algorithm for the biofilter design process based on media airflow characteristics and particle sizing. Biofiltration technology for reduction of emissions from swine wean-to-finish confinement buildings was also tested. A set of five similar swine buildings on a single farm [one control and two sets of two buildings for treatments] were instrumented with continuous air sampling equipment. Final data analysis showed the effectiveness of the emission control systems.

Results

Biofilter experiments and demonstrations give livestock producers new information regarding the selection of, and investment in, emission control technologies for mechanically ventilated animal buildings. Research results have allowed us to develop new tools for teaching biofilter design and management to producers, contractors, consultants, agencies, and other stakeholders. We held two workshops for agency staff, farmers, and agribusinesses to demonstrate biofilter construction and maintenance.

4. Associated Knowledge Areas

KA Code	Knowledge Area
133	Pollution Prevention and Mitigation
141	Air Resource Protection and Management
401	Structures, Facilities, and General Purpose Farm Supplies
402	Engineering Systems and Equipment
404	Instrumentation and Control Systems

Outcome #8

1. Outcome Measures

Development And Use Of A Manure Management Plan

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2013	123

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Improper manure management has environmental consequences and livestock and poultry producers face challenges in understanding and minimizing these negative impacts.

What has been done

Educational efforts included: [1] Continued maintenance and updating of the Illinois Manure Management Planner website [<http://web.extension.illinois.edu/immmp/auth/login.cfm>] which is used by stakeholders to learn about manure management and to access resources to create Manure Management Plans for facilities; [2] Training, certification and testing programs were conducted for custom manure haulers [operators who haul and apply manure to cropland for hire are not regulated in Illinois, but through collaboration with other Great Lakes states a voluntary training and certification program is provided]; [3] Annual training for the Certified Livestock Manager Training program was conducted at eight sites across the state. This state program requires livestock and poultry producers to attend training and become certified once every three years. The curriculum includes key information on best management practices, nutrient management information, and updates on regulations and associated information; [4] Input was provided for a Comprehensive Nutrient Management Plan [CNMPS] course curriculum being developed by another state similar to the one developed in Illinois to certify Technical Service Providers [TSPs] who act as consultants for livestock producers that must implement improvements to manure management plans on their farms. These TSPs specialize in developing comprehensive nutrient management plans for producers that are actively using conservation practices and implementing the latest best management practices.

Results

Results included: [1] The Illinois Manure Management Planner website received 7,115 accesses, with 65 new accounts created, and 58 plans updated and/or modified; [2] Forty-two manure haulers, environmental managers and their employees attended the Custom Applicator Training program. Collectively, their production units and clients represented over 500 million gallons of annual manure application. All 42 individuals passed the Level Two exam for custom applicator certification; [3] Two hundred seventy-four [274] individuals attended the Certified Livestock Manager Training programs. According to the survey data, 88% of attendees responded that they currently had manure management plans. Of these respondents, 50% updated and used their plan annually.

4. Associated Knowledge Areas

KA Code	Knowledge Area
112	Watershed Protection and Management
133	Pollution Prevention and Mitigation
141	Air Resource Protection and Management
403	Waste Disposal, Recycling, and Reuse

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Natural Disasters (drought, weather extremes, etc.)
- Economy
- Appropriations changes
- Public Policy changes
- Government Regulations
- Competing Public priorities
- Competing Programmatic Challenges
- Populations changes (immigration, new cultural groupings, etc.)

Brief Explanation

V(I). Planned Program (Evaluation Studies)

Evaluation Results

Commercial Pesticide Applicator Training

A survey of practice changes was mailed to a random sample of 498 of the 5,874 participants in the 2011-12 Commercial Pesticide Applicator training program. The 295 completed surveys represented 59% of those who completed the survey. In response to the question asking them how much they had improved implementation of practices as a result of the training, 188 [65.7%] indicated improving calibration procedures [frequency, accuracy, and measurement], 154 [53.8%] improved equipment maintenance [inspecting, cleaning, and replacing worn nozzles], and 151 [52.8%] improved changing type, size, or materials for the nozzles used.

Key Items of Evaluation