

March 2017 - February 2018

Advisory Board Report



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UNIVERSITY OF
Nebraska
Lincoln

ILLINOIS STATE
UNIVERSITY



The DIFM project is funded by USDA National Institute of Food and Agriculture grant 2016-68004-24769.

Agenda

11:00-11:15	Welcome and Introduction (David Bullock)
11:15-11:30	Water Monitoring (Jason Kandume)
11:30-11:45	Field Trials in Illinois and Beyond (German Mandrini)
11:45-12:15	Educational Activities (FAB Fellows - Luis Rodriguez; Students - Caitlin McGuire; Graduate Student Research Progress - Aolin Gong, Brittani Edge, German Mandrini)
12:15-12:45	Software Development (Data - Nicolas Martin; Trial Design - Brittani Edge; Analysis of Data - Aolin Gong)
1:00-1:15	Weigh Wagon Experiment (Tony Grift)
1:15-1:30	Break
1:30-1:45	Research Activities at Other Universities (Caitlin McGuire)
1:45-2:00	Argentina Field Trials (Laila Puntel)
2:00-2:15	What We Are Beginning To See in the 2017 Data, How We Think We Can Get Better Data (David Bullock)
2:15-2:30	Budget Presentation (Caitlin McGuire)
2:30-3:00	Discussion, Questions, Comments, Etc. (Led by David Bullock)
3:00-3:30	Advisory Board Meets To Plan Process of Writing Up Comments and Advice

Half-Time Check-In

Our Goals

At the initiation of the Data-Intensive Farm Management project, we had a few overall goals:

1. Expanding our current close collaboration with farmers conducting large-scale, on-farm field trials into an on-farm research/extension/teaching infrastructure.
2. Conducting hundreds of international trials.
3. Conducting analysis of that data and to efficiently return the information thus learned to farmers in the form of improved fertilizer management advice, and to government in the form of better information about how proposed policies will impact water quality and farm income.
4. Providing rigorous quantitative and data-centered training in the agricultural sciences to a few undergraduate and graduate students who have or will obtain the language skills necessary to take advantage of burgeoning U.S.-South American business and agricultural research opportunities.

Towards these ends, by the end of the second year, our goals were to have conducted 36 international trials, brought two undergraduate and two graduate Spanish-speaking students to the project, and have developed a working beta version of the On-Farm Research Design software.

How Did We Do?

We met our goals! As of the end of the second year of our project, we have conducted 36 field trials in Argentina alone! In total, we've conducted 61 trials. At present, we have 10 Spanish- or Portuguese-speaking students working on the project, and we have a working beta version of the On-Farm Research Design software.

Looking forward, we hope to bring on an additional Spanish-speaking undergraduate student, to better automate the On-Farm Research Design software to reduce the burden for researchers designing field trials, and to complete 100 trials in the 2018!



Reflections on 2016 Advisory Board Report

Our Insights

We described two significant insights in our 2016 Advisory Board report: a need for increased annual soil characterization and the benefits of working with both medium-sized and large commercial farming operations.

The need for increased annual field characterization arose from a lack of information about soil composition and texture, which might affect experimentation results. As we will discuss in greater detail in our section on field characterization, we bought a Veris U3 to better map trial fields in our project.

However, we did deviate from our plans to focus on larger farm recruitment. While we had intended to emphasize these farms in our recruitment for next year's trials, active recruitment has proved unnecessary as a result of word-of-mouth advertising. At present, we are planning 100 trials for 2018, which exceeds our initial plan of 29 by 71.

51 of these trials will be conducted internationally, and therefore will not be paid for through domestic funding. We will be funding the remainder of these additional trials through a combination of the USDA DIFM funding, as well as through funds attained by David Bullock and Luciano Shozo Shiratsuchi.

Your Concerns

We want to thank you, first and foremost, for both your compliments and criticisms. Without your input and guidance, we would not be able to work as smoothly as we do at present!

One resounding issue raised in your report to us from our work in 2016 was related to communication. Dixie Jackson commented that "The program's monthly newsletter is informative, but some issues would have benefitted from more careful editing." In response

to these concerns, following Krystal Montesdeoca's resignation, the DIFM project recruited her replacement through the English department at the University of Illinois, and hired Caitlin McGuire as the Project Coordinator.

Caitlin McGuire has a BA in English from the University of California, Berkeley, and an MFA in Creative Writing from the University of Illinois. She has three years of experience in project management, taught rhetoric at the University of South Carolina and at the University of Illinois, and has been a professional writer for nearly a decade. McGuire co-wrote and edited the Data-Intensive Farm Management team's successful application for a FACT Workshop grant through the USDA, has redesigned our website and has begun writing our newsletters at a professional caliber of writing, as Ms. Jackson has noted in a previous email.



Updates to the DIFM Project

The Data-Intensive Farm Management program has had a few notable updates to our staffing in our second year. We've had several scholars leave the project, and have added new researchers, a new Visiting Research Coordinator, and have expanded our research into new areas of the country.

Leaving the Project

Dr. Donald Bullock, previously of the Data-Intensive Farm Management's crop sciences division, retired from the University of Illinois in 2017.

Nathan Casler, a research programmer who helped develop the On-Farm Research Design software, left the National Center for Supercomputing Applications to work as a Geospatial Software Engineer at Planet in San Francisco, California.

The University of Kentucky is no longer a DIFM subawardee.

Joining the Project

Caitlin McGuire was hired as a part-time Project Coordinator in February of 2017, but was promoted to a full-time Visiting Research Coordinator in November of 2017. She is pursuing project management professional certification in the coming months to ensure the future success of the Data-Intensive Farm Management project. Funds and performance permitting, she will continue in this position for the duration of the project.

Dr. Nicolas Martin joined the Data-Intensive Farm Management project in 2017. Martin's undergraduate degree is in Agronomy at University of Mar del Plata; his graduate studies at the University of Illinois focused on studying Soil-Plant relationships with multivariate analysis and spatial statistics. After graduation, Martin worked for more than 10 years in the seed industry developing drought-tolerant corn hybrids and using large geospatial datasets to position trials and soybean varieties in the marketplace. As an Assistant Professor at the University of Illinois, he hopes to improve the long-term profitability and stability of cropping systems by exploring applications of quantitative methods on big data. He is interested in interdisciplinary efforts to expand the frontiers of agricultural research and study effective approaches to implement new insights and discoveries in agricultural decisions and operation.



Dr. Bruce Maxwell has helped to expand the scope of the Data-Intensive Farm Management project since he was added to the DIFM project as a co-PI in 2017. Dr. Maxwell is a professor of Agroecology and Applied Plant Ecology in the Department of

Updates to the DIFM Project

Land Resources and Environmental Science at Montana State University. He was instrumental in creating the interdisciplinary Sustainable Food and Bioenergy Systems undergraduate degree program at Montana State University and was co-Principal Investigator of the Montana Research and Economic Development Initiative project on agricultural management optimization under high uncertainty. He is the co-director of the MSU Institute on Ecosystems and was lead author for the Agriculture Sector of the Montana Climate Assessment.

Dr. Maxwell cowrote our successful application to the USDA for the FACT Workshop to Establish a Research Cyber-Infrastructure for On-Farm Experimentation. We hope to add Dr. Maxwell and Montana State University as a subawardee to our grant for the duration of the project.



Dr. Haiying Tao is an assistant professor of Soil Fertility and Residue Management in the Department of Crop and Soil Sciences at WSU. Her research programs focus on fertility management and strategies to improve soil health for WA agricultural systems. She is currently leading an effort to de-

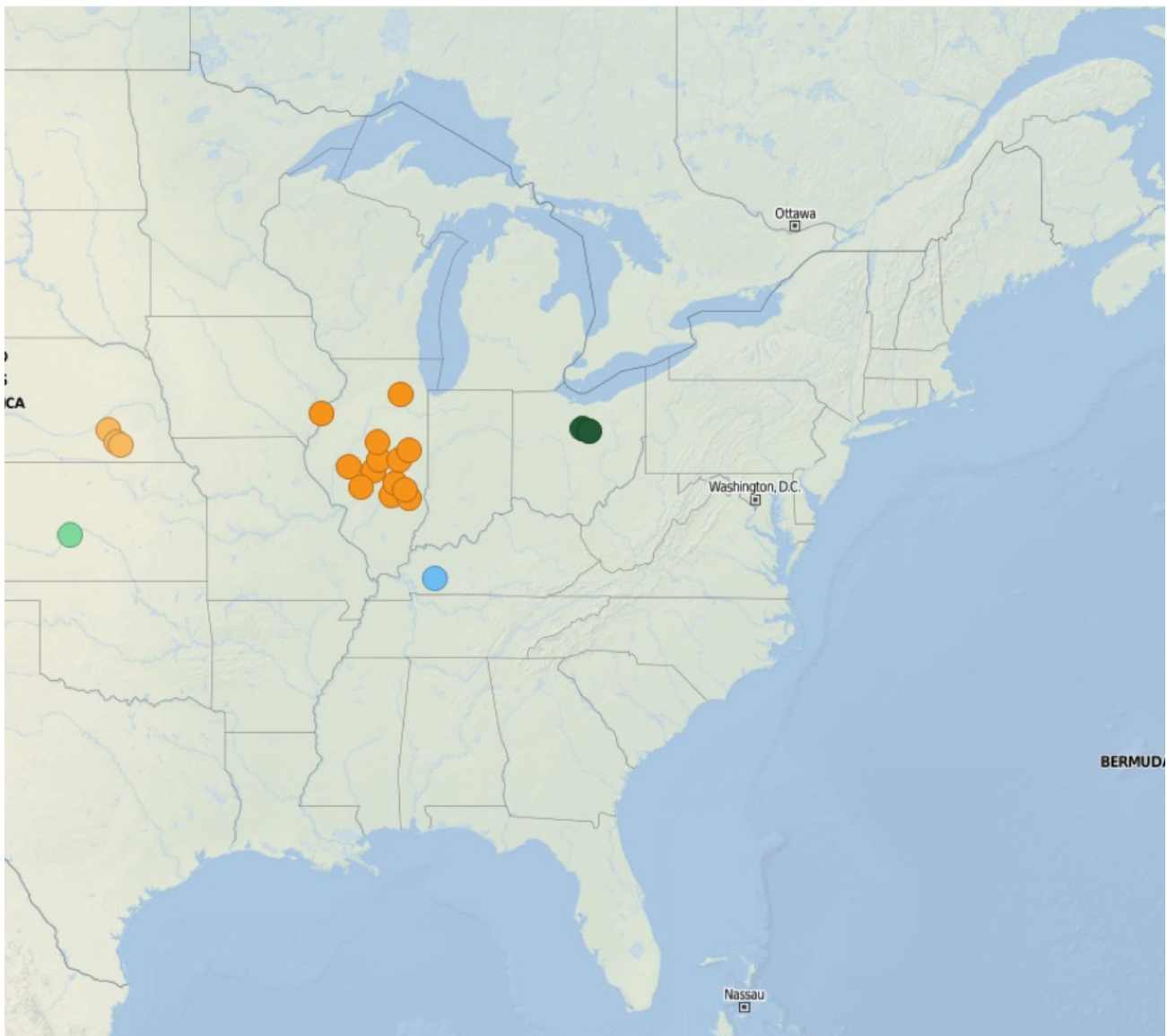
velop a farmer's network, which will be a platform for information sharing, participatory learning and on-farm research using precision agricultural technologies. Dr. Tao cowrote our successful application to the USDA for the FACT Workshop to Establish a Research Cyber-Infrastructure for On-Farm Experimentation.



Due to the addition of Dr. Bruce Maxwell and Dr. Haiying Tao, we will now be able to begin designing field trials in the Pacific Northwest and Montana, which presents a unique opportunity to design field trials on terrain with topography very different than what we experience in the Midwest.

Trial Locations and Recruitment

The DIFM project greatly surpassed our expectations for farmer recruitment in 2017. Though we originally promised 22 trials, we conducted 10 trials in Illinois, 1 trial in Kansas, 3 trials in Nebraska, 2 trials in Ohio, 3 trials in Brazil, and 18 trials in Argentina. Altogether, we ended up working on 34 fields, exceeding our goals by 12 fields.



Current recruitment projections for 2018 are looking even better. As we will discuss in further detail later in this document, the DIFM project has developed or is developing relationships with Washington State University, Montana State University, the Ontario Ministry of Agriculture, Grain Growers of Ontario, Guelph University, the Food and Agriculture Organization of the United Nations, and the Advanced Agriculture Alliance, and the New York Corn and Soybean Growers Association, as well as with Veris Technologies and IntelinAir.

In 2017, we followed our plan from the Advisory Board Report in 2016 to pursue larger farms. We successfully recruited farms exceeding 500 acres in Illinois, Ohio and Kansas. Veris Technologies has put us in contact with three farmer consultants who are committed to working with us, and as a result of an interview in the High Plains Journal, we've had farmers coming to us to request that we run trials on their fields! As a consequence, we are slowing our recruitment efforts in 2018, to concentrate on efficiently running and analyzing the data from existing field trials.



Our most optimistic estimate for next year:

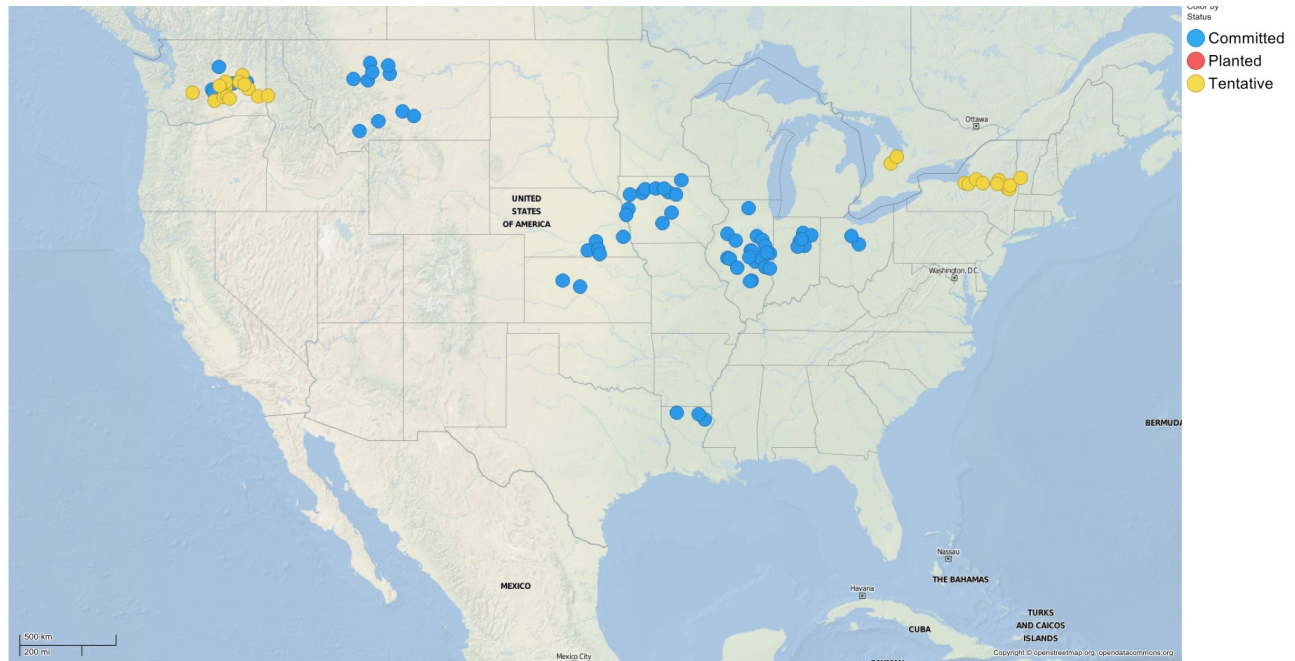
36 in Argentina	1 in Idaho
8 in Brazil	12 in Iowa
3 in Colombia	2 in Kansas
2 in Canada	5 in Nebraska
6 in Montana	2 in Ohio
25 in Washington	3 in Indiana
10 in New York	20 in Illinois
3 in Louisiana	

Next Year s Field Trials

Number	Location	Crop	Research Partner
36	Argentina	Corn and Wheat	Clarion
8	Brazil	Cotton	Empresa Brasileira de Pesquisa Agropecuária
2	Canada	Corn	The Ontario Ministry of Agriculture, Grain Growers of Ontario, Guelph University
3	Colombia	Cotton	The Food and Agriculture Organization of the United Nations
1	Idaho	Wheat	Washington State University
20*	Illinois	Corn	Individual farmers, HarvestTime Management. Tentative: Evergree FS
3	Indiana	Corn	Forefront Ag Solutions
12	Iowa	Corn and Soy	Iowa Soybean Association
2	Kansas	Wheat	Individual Farmers
3	Louisiana	Cotton	Louisiana State University
6	Montana	Wheat	Montana State University, Individual Farmers
5	Nebraska	Corn	University of Nebraska, Lincoln Individual Farmers
10*	New York	Corn and Soy	Tentative: New York Corn and Soybean Growers Association
2	Ohio	Corn	Individual Farmers
25*	Washington	Wheat	Washington State University Tentative: Consulting Firm

Note: An asterisk indicates that these numbers remain tentative.

Trial Locations in 2018



Field Characterization

In order to improve field characterization in the DIFM project, we have chosen to focus on two principal forms of characterization: electroconductivity and aerial imagery. Electroconductivity readings of a field allow us to map soil texture and composition. Aerial imagery uses infrared photography to determine crop “color,” which can provide evidence of nitrogen stress.

In 2017, we allocated \$27,000 in otherwise unused funds to the purchase of a Veris U3 machine. The U3 takes readings of electroconductivity of organic matter. Robert Dunker has been generating data by driving the U3 over two fields in Illinois to date, with many more planned for the spring of 2018.

As a result of our research, Veris Technologies has offered to take electroconductivity readings of farms in Iowa if needed. Our work with Veris has proved very successful; the company has included information about the Data-Intensive Farm Management project in their newsletter, which has provided us with a larger audience, and has put us into contact with three consulting firms, which has been a tremendous aid to our recruiting efforts.

We have also begun partnering with IntelinAir, an aerial imagery company. To date, they’ve taken images of one of the fields in our project, and are looking for additional ways to collaborate.



Agronomist Robert Dunker drives the Veris machine across the Morrow Plots, the oldest experimental crop field in the United States. For the first time in 136 years, soil on this field is measured by an optical sensor, without removing any soil.

Student Training

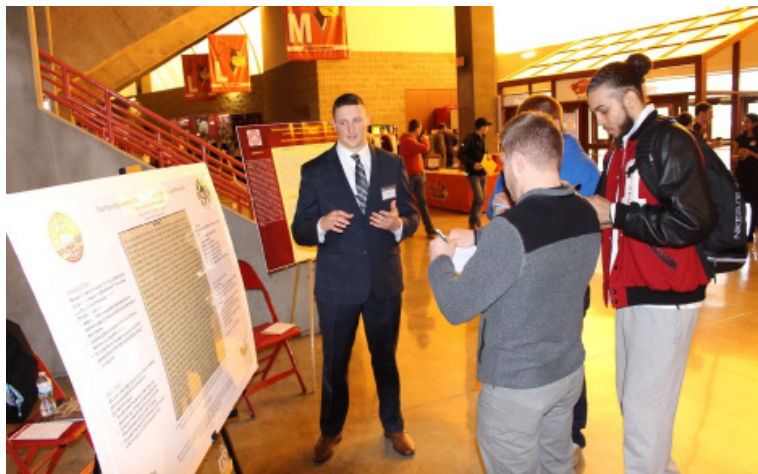
One of the central goals of the DIFM project was the preparation of undergraduate and graduate students for the burgeoning opportunities available in the agricultural sciences. We intended for undergraduate students to gain training primarily through the FAB Fellow program, and to fund both FAB Graduate Fellows and traditional graduate students.

As of 2017, we have 6 undergraduate students and 18 graduate students working on the project. 2 of our undergraduates and 8 of our graduate students are fluent or learning Spanish or Portuguese, which exceeds our initial goal by 6.

Undergraduate Students

RJ Baldwin, BS. Baldwin worked with Nebraska DIFM project datasets in the fall of 2017 and was responsible for collecting soil sample data and pre-processing as-applied data and harvest data to prepare those datasets for further analysis. (University of Nebraska, Lincoln, with Dr. Luck). August 2017-May 2018. (4 months, part time)

Benjamin Marks, BS. Trained in human subjects research and interview design; his efforts resulted in two poster presentations. (Illinois State University, with Dr. Boerngen). August 2016-May 2017. Part-time.



FAB Fellows

Raagini Gupta, BS. Gupta has studied the connections between computer science, natural resources, and environmental science and has declared a minor in computer science. (University of Illinois, with Dr. Rodriguez). August 2017-May 2018.

Aiden Kamber, BS. Kamber plans to do research this summer involving Big Data and the agriculture industry. (University of Illinois, with Dr. Rodriguez). August 2017-May 2018.

Elisa Kim, BS. Kim is developing her skills in hydrology, GIS, statistics, logistics, supply chains, and cost analysis in the depth of training in food and agriculture and Big Data. She will be applying these strengths in a water and soil engineering internship over the summer as well as continuing her research project regarding flow cytometry over the next coming months. (University of Illinois, with Dr. Rodriguez). August 2017-May 2018.

Kelsey Schreiber, MS. Schreiber is looking at increasing the effectiveness of international engineering efforts targeting water and irrigation systems to increase rural water access. She is utilizing qualitative and quantitative datasets to pinpoint the conditions by which project stakeholders judge success, ultimately hoping to analyze social media patterns to provide a more candid validation of her model. Along with her thesis she plans to submit a portion of her research for publication and to present it to colleagues in the industry. (University of Illinois, with Dr. Rodriguez and Dr. Hansen). August 2017-May 2019.

Brandon Tate, MS. Tate is investigating soil sensing technologies related to the physical and electrical properties of soils. His deliverable will be a thesis and journal

Student Training

articles detailing conducted research. (University of Illinois, with Dr. Rodriguez). August 2017 – May 2020.

John Winkler, BS. Winkler is working as an undergraduate research assistant under Dr. Rodriguez, working with GIS to study viable plots for biomass crops along state roadways. His possibly deliverables will include participation in the undergraduate research symposium. (University of Illinois, with Dr. Rodriguez). August 2017-May 2018.

Graduate Students

Nidhi Adhikari, MS. Adhikari is developing an excel-based hydrology model for evaluating drainage system response to future climate scenarios. Hydrologic simulations from the model are used to determine the depth and spacing of tile drains that maximize crop yield for corn and soybean during the mid and late 21st century. Her deliverable will be her thesis and a journal article. (University of Illinois, Department of Agricultural and Biological Engineering, with Dr. Cooke). May 2016- May 2018.

Brittani Edge, Ph.D. Edge is researching management zone delineation to determine whether current practices could be improved in terms of profit for producers. She will be giving an oral presentation at the International Society of Precision Agriculture in June 2018 and will write her second-year paper and dissertation on this research. (University of Illinois, Department of Agriculture and Consumer Economics, with Dr. Bullock). August 2016-May 2020.

Zhengzheng Gao, MS. Gao has received training on spatial data management, graphing using R, and creating maps. These trainings have helped her to analyze the data generated through on-farm experiments. She is expected to com-

plete a thesis by using on-farm experiment data from this project. (University of Nebraska, Lincoln with Dr. Mieno). August 2017-May 2019. Part-time.

Paula Girón, MS. Girón collaborated in harvesting trials, cleaning yield and electroconductivity maps, and designing new experiments. She will begin her doctorate in Agricultural Sciences in 2018, and will continue to work with the DIFM project's Argentine trials. (University of Illinois, Department of Agriculture and Consumer Economics, with Dr. Bullock). September 2017-December 2020. Part-time.



Aolin Gong, Ph.D. Gong is currently using a crop simulation software and R program to investigate the optimal length of the plot trials so that more observations will be aggregated within a field. Her deliverable will be her second year paper and her dissertation paper. (University of Illinois, Department of Agriculture and Consumer Economics, with Dr. Bullock). August 2016-May 2020. Full-time.

Hao Hu, Ph.D. from Department of Geography and Geographic Information Science. He started working with Dr. Bullock and his team on the DIFM project since Oct. 2017. He helped with the on the National Science Foundation (NSF) white paper on "Seeking Community Input for Topic Ideas to Accelerate Research Through International Network-to-Network Collaboration". Currently, he is working on preprocessing trials data collected from various farms. He is interested in developing spatial regression models to study the relationship between crop yield and farm management practice. He ex-



Student Training

pects to develop a journal article with the results of his research. (University of Illinois, Department of Geography and Geographic Information Science, with Dr. Wang). August 2017-May 2018. Full-time.

George Hoselton, MS. Hoselton has been trained in human subjects research, will be trained in survey design and survey data analysis, and will be conducting a large-scale survey via the Illinois Corn Growers Association for his master's thesis research. This thesis will result in at least one peer-reviewed manuscript. (Illinois State University, with Dr. Boerngen). December 2017-May 2019. Half-time.

Wilman Iglesias, Ph.D. Iglesias is a volunteer who participated in the development and application of models for evaluation the payoff for variable applicator rate, and will continue to be involved in the coming year. (University of Nebraska, Lincoln, with Dr. Fulginiti and Dr. Perrin). August 2017-May 2018. Part-time. (3 months.)

Shreya Khurana, MS. Khurana is a volunteer working on statistical data analysis of the crop and field trials and is using data tools to effectively compare the seed rate and the yield output as well as the fertilizer impact. Her deliverable will be a data module that scores the effect of fertilizer application. (University of Illinois, Department of Statistics, with Dr. Bullock). October 2017-May 2018. Part-time.

German Mandrini, MS. Mandrini is using crop simulation software to compare different strategies that could be used to run trials over a field to find the optimal stopping time where the farmer will finish running trials and move to regular production using the information of those trials to adjust the input's rate. His deliverable will be his thesis and possi-



bly a journal article with the results of his research. (University of Illinois, Department of Agriculture and Consumer Economics, with Dr. Bullock). June 2017-December 2018.

Jayash Paudel, Ph.D. Paudel has been collecting and analyzing data on United States county-level fertilizer use, weather variation (temperature and rainfall), and water quality, with the goal of estimating the relationship between fertilizer use and water quality at the watershed level. Climatic data (past and projected) will be used to estimate the relationship between weather and fertilizer use, and determine what the implications of future climate change will be for fertilizer use and its subsequent impact on water quality. (University of Massachusetts, Amherst, with Dr. Crago). May 2016 - December 2018. Part-time.



Laila Puntel, Ph.D. Puntel helped run 36 trials in the North West region of Buenos Aires province and the Center of Chaco province. Trials were established on maize (2016-2017

and 2017-2018) and on wheat (winter 2017). Results will be presented at several meetings with the participants, conferences (International Society of Precision Agriculture, Quebec, Canada, 2018), and possibly published in a peer review journal. Puntel

coordinates the implementation of the trials, data collection, and data analysis in collaboration with the DIFM research team. (Iowa State University, with Dr. Archontoulis). August 2016-May 2020.

Pedro Queiroz, Ph.D. Queiroz is a volunteer who participated in the development and applica-

Student Training

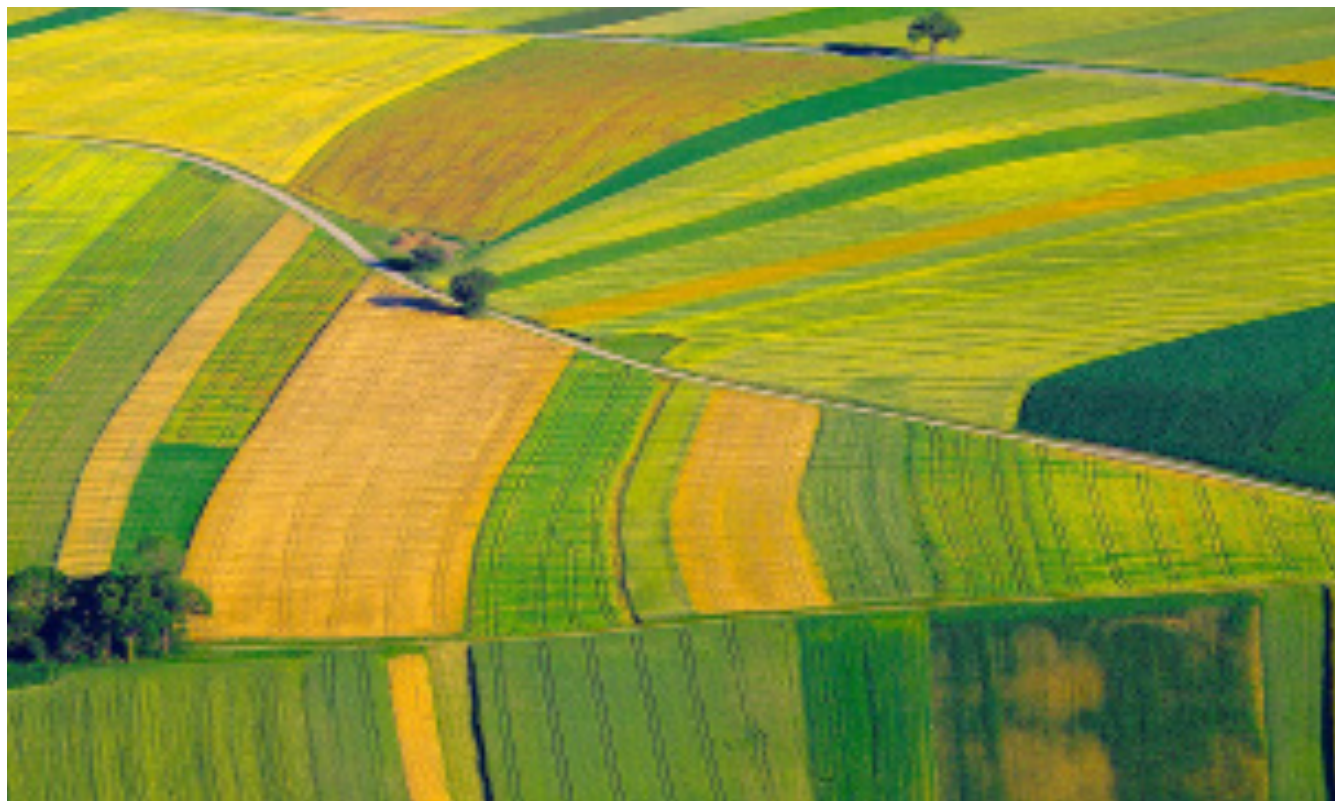
tion of models for evaluation the payoff for variable applicator rate, and will continue to be involved in the coming year. (University of Nebraska, Lincoln, with Dr. Fulginiti and Dr. Perrin). August 2017-May 2018. Part-time. (3 months, part-time)

Robert James Reis, Ph.D. Reis gathers machine data from farm machinery used in the DIFM project and aids in the development of models for predicting yield based on machinery data. Additionally, he is developing a sensor system to measure soil type and compaction. His deliverable to date is a poster presentation to Dow AgroSciences. Future deliverables are his dissertation and journal articles from the results of his research. Other potential community resources that could be generated from this research are patents around the sensor system. (University of Illinois, Department of Agricultural and Biological Engineering, with Dr. Grift). August 2016-May 2019.



Felipe Silva, Ph.D. Silva is a volunteer who participated in the development and application of models for evaluation the payoff for variable applicator rate, and will continue to be involved in the coming year. Future deliverables include a journal article describing the EVSI model and its application to project field data. (University of Nebraska, Lincoln, with Dr. Fulginiti and Dr. Perrin). August 2017-May 2018. Part-time. (3 months, part-time)

Gabe Stoll, MS. Stoll was responsible for coordinating data collection with the four Nebraskan cooperators during the fall harvest activities and consolidating the data for analysis. Stoll will coordinate with 2018 growers to collect pre-season data and deliver prescription maps for field applications. He will also monitor fields and collect harvest data in the fall. (University of Nebraska, Lincoln, with Dr. Luck). June 2017-December 2018. Full-time.



Other Research Activities on the DIFM Project

Water Monitoring Activities

Three experimental sites have been instrumented with water collection systems. The water collection systems consist of control structures installed in-line with the subsurface drainage tile lines. One or more control structures have been installed on each to collect the majority of the drainage water from the experimental area. In some cases, the drainage networks overlap with adjacent fields.

In these cases, control structures have been installed at both the upslope and downslope ends of the experimental areas. Each water collection system is also equipped with a pressure transducer and v-notch weir, allowing the depth of water to be measured (pressure transducer) and the water flow rate to be calculated (from the v-notch weir calibration). Grab samples of water are collected multiple times from each field by a field technician and analyzed for nitrate-N and orthophosphate.

The first field (Rohrscheib) was installed in December 2016. The second and third fields (Sasse and Wendte) were installed in December 2017.

DIFM in Argentina

Laila Puntel, PhD student at Iowa State University and Dr. Agustin Pagani from Clarion (Nueve de Julio, Buenos Aires, Argentina) ran 36 trials in the North West region of Buenos Aires province and the Center of Chaco province. Trials were established on maize (2016-2017 and 2017-2018) and on wheat (winter 2017). Treatments consisted in different levels of nitrogen that varied from 0 to 300 kg N ha⁻¹ and seeding rate that varied from 45 to 95 plant ha⁻¹ in most of the cases.

Data from the first year of experimentation is currently being analyzed with the aim to better understand how the yield response to nitrogen varies across fields and find the optimum nitrogen rate that maximize profits.



ABE visitor Ikuma Ono and visiting researcher Paula Giron stand in a field near a combine during a weigh wagon trial.

Weigh Wagon Trials

Dr. Tony Grift and Robert Reis conducted trials to measure per-plot corn yield on DIFM-affiliated fields. These tests should help not only to determine the accuracy of the yield monitor's combine, but also to determine its latency time in order to determine how long it takes the machine's yield monitor to respond to a new (quasi-constant) yield level.

To do this, Dr. Grift and Reis used a Trimble RTK-GPS Rover to place flags indicating pre-calculated combine stopping points. After the combine comes to a full stop, its tank is unloaded into a weigh wagon which, after weighing, unloads into a regular grain wagon.

Visiting Researchers

Two Professors of agricultural statistics from the National University of Cordoba, Argentina, visited the University of Illinois campus in July. Prof. Cecilia Bruno spent three weeks, and Prof Monica Balzarini spent one week. They worked with existing data, and began to conceptualize statistical computer programs to

Other Research Activities on the DIFM Project



A farmer stands in a field during Dr. Bullock's trip to the Pacific Northwest

semi-automatize our methods of data and economic analysis. The long-run goal here is to make it feasible for DIFM to be able to analyze data coming from hundreds, or even thousands, of field trials every year, and in this way provide farmers from all over the world with data-based management advice.

On July 5, David Bullock, Taro Mieno, Nicolas Martin, and Monica Balzarini and Ceci Bruno met in Ankeny, Iowa with Scott Nelson and Peter Kyveryga. Nelson is the Director of the Iowa Soybean Association's On-Farm Network. Kyveryga is the Director of ISA's Research Analytics program. Discussions were held about working with ISA to run DIFM trials on twelve fields in 2018.

Farming in the Palouse

Site-specific farm input management is particularly important when there are large differences in growing environments within a field. The Palouse, a wheat-producing region in western Washington and the stovepipe of Idaho, features exceptionally hilly terrain. Steep hills

make it impossible for farmers to drive equipment in straight lines for long periods of time.

To take advantage of the opportunities made available by the Palouse's dramatic terrain, the DIFM project has begun working with Dr. Haiying Tao of Washington State University to run field trials in the Palouse region.

NSF White Paper

Grad student Hao Hu and Project Coordinator Caitlin McGuire are collaborating on a white paper for the National Science Foundation. In September, the NSF called for proposals identifying areas in science, engineering, or STEM education that would benefit from international network-to-network collaboration in order "to accelerate discovery and advance research outcomes."

Their white paper argued for the necessity of international network collaboration in precision agricultural research. This paper will hopefully pave the way for future grant opportunities that will aid in establishing

Other Research Activities on the DIFM Project



A field trial design in the hilly Palouse region of the Pacific Northwest.

an international cyber-research infrastructure for DIFM and similar projects.

Mechanical Engineering

One of the many research challenges put forth by the rugged terrain in areas like the above-mentioned Palouse is one of ability: that farmers simply cannot apply experiments on rectangular grids. To compensate for this problem, Alexandre Ormiga Galvao Barbosa, a Ph.D. student in Mechanical Engineering from the University of Illinois, has created software that designs field trials that follow “as-applied” paths made by farm equipment when applying inputs in earlier year. The figure above illustrates one such design for part of an Idaho field.

Illinois State University

Team members at Illinois State University have worked in collaboration with the McLean County (IL)

Soil and Water Conservation District Board of Directors to interview local farmers about their awareness of, and attitudes toward, issues of nutrient loss reduction and the impact that nutrient loss has on their farming operations.

This phase of the project proceeded on schedule, with interviews completed in 2016 and two public presentations of research findings in 2017.

University of Nebraska, Lincoln

The Fulginiti-Perrin research team completed preliminary evaluation of the payoff from VAR (variable application rates) for N at two project fields in Illinois. We conceptualize that payoff as the expected value of obtaining a soil characteristic signal for a grid

prior to choosing the N rate. The ex-post value of obtaining the soil EC (electrical conductivity) signal was low, averaging \$1.00/acre on one field, \$0.58/acre on the other. Whether this disappointing result was due to relatively uniform grids across the field, or to weak correlation between EC and N response, remains to be determined.

Subsequent team activity was directed toward the adaptation of a Bayesian model for determining the expected value of the signal (rather than ex-post), following classic development of models of EVSI (expected value of sample information). This will allow us to evaluate the expected payoff of VAR on a particular field, given some characteristics of the field. Subsequent team activity was directed toward the adaptation of a Bayesian model for determining the expected value of the signal (rather than ex-post), following classic development of models of EVSI (expected value of sample information).

FACT Workshop

Other Research Activities on the DIFM Project



Margaret Krause, in the picture above, has since put the DIFM project in contact with the New York Corn and Soy Grower's Association, and we are currently discussing running 10 trials in the region in the 2018-2019 growing season.

imentation.

We are still in the early stages following this workshop; consequently, many of these goals have not yet been reached. However, in the last month, the DIFM project has begun planning and developing 12 trials in New York and Ontario as a result of our contact with two attendees: Margaret Krause, of Cornell University and the New York Corn and Soybean Growers Association, and Nicole Rabe, of the Ontario Ministry of Agriculture.

Additional conversations are scheduled to take place during the International Society of Precision Agriculture, at which Laila Puntel and Brittani Edge will be giving oral presentations based on their work with project.

Dr. David Bullock, Dr. Bruce Maxwell, Dr. Haiying Tao, and Dr. Anand Padmanabhan received a \$50,000 Food and Cyberinformatics and Tools Workshop grant to host "A Workshop to Plan an International Cyber-infrastructure for On-farm Production Research" in Los Angeles from December 15-18, 2017.

The purpose of this workshop was to bring together international scholars interested in the use of on-farm field trial data to incorporate the consideration of spatial and temporal variation into farm management. Following the workshop, we hoped to create a detailed blueprint for a cyber-infrastructure to support international collaboration in on-farm precision experimentation, a detailed agenda for developing the foundation and framework of that infrastructure in 2018, identification of immediate opportunities for international collaboration on on-farm research, development of a vision of how our approach, data, and analysis could influence local, regional, and national agricultural and climate policy, and identification of data sources currently available to support on-farm trial exper-



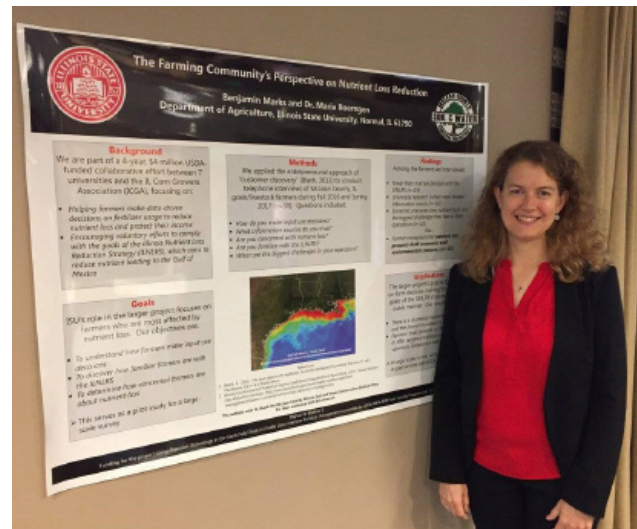
Products of the DIFM Project

Student Work

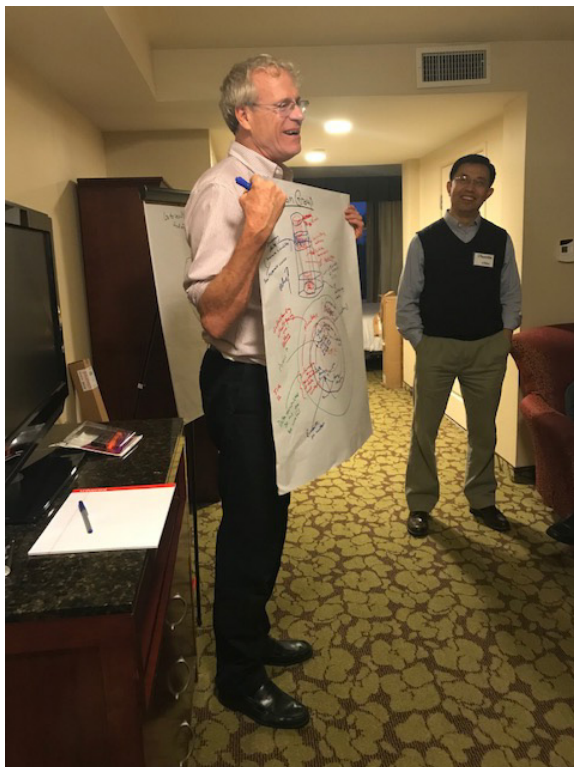
On January 29, 2018, at the University of Massachusetts, Amherst, Jayash Paudel successfully defended his dissertation proposal, which consists, in large part, of analysis related to this project.

Benjamin Marks, an undergraduate research assistant, had a poster presentation at the Illinois State University Research Symposium in Normal, IL, February 2017.

German Mandrini is at work on his master's thesis, entitled "On-Farm Field Trials: Optimal Stopping Time and the Value of Statistical Efficiency." Mandrini will use crop simulation software to compare different strategies that could be used to run trials over a field



Dr. Boerngen presents a poster in Boise, Idaho.



to find the optimal stopping time where the farmer will finish running trials and move to regular production using the information of those trials to adjust the input's rate. These procedures will allow us to assign economic costs and benefits to these trials.

Aolin Gong is working on a second year paper, titled "Determining the Optimal Plot Length in On-Farm Field Trials." In this paper, Gong will be determining the optimal plot length by calculating the necessary length that will allow the yield monitor to report the true yield within that plot. She will then incorporate that length into economic models to determine the optimal plot length in on-farm field trials.

Brittani Edge is working on a second year paper as well, titled "An Economic Theory-Based Approach to Management Zone Delineation." In this work, she will compare the resulting profits from two types of management zone delineation: the traditional clustering with yield and variables associated with yield, and a

second, theory-based approach. This second approach will use microeconomic theory to determine the soil and field characteristics that form management zones for nitrogen applications.

Alexandre Ormiga Galvao Barbosa, a Ph.D. student in Mechanical Engineering at the University of Illinois, is working on his dissertation. One component of his dissertation will be a chapter on the use of artificial intelligence as a means of determining the optimal coverage of fields. This will provide information regarding the most efficient route for farmers to drive on fields and will aid in the design of field trials, particularly in the hilly areas of the Palouse.

Brittani Edge and Laila Puntel will be giving oral presentations regarding their work on the Data-Intensive Farm Management project at the International Conference on Precision Agriculture in June, 2018, in Montreal.

Professor's Work

Dr. Boerngen, assistant professor of Agribusiness, had a poster presentation at the WERA-72 Annual Conference in Boise, ID, June 2017.

Dr. Bullock, Dr. Martin, and Robert Dunker presented findings at the FACT Workshop to Establish a Cyber-Infrastructure for On-Farm Experimentation.

The High Plains Journal interviewed Keith Glewen, Dr. Joe Luck, and Dr. David Bullock regarding the Data-Intensive Farm Management project.

Dr. Christine Crago has presented the results of preliminary analysis at the University of Massachusetts Environmental Working Group.

Additional Funding

Dr. David Bullock, Dr. Bruce Maxwell, Dr. Haiying Tao, and Dr. Anand Padmanabhan received \$50,000 from the USDA for their Food and Cyberinformatics

and Tools Workshop grant, entitled "A Workshop to Plan an International Cyber-infrastructure for On-farm Production Research." This workshop was held in December 2017.

Dr. David Bullock and Dr. Luciano Shiratsuchi Shozo received a \$20,000 University of Illinois College of ACES Office of International Programs Joint Research Grant for their application, entitled "Putting More Data into Data-intensive Nitrogen Management: Using Precision Technology to Conduct Large-scale Field Trials in Brazil and the US." This grant will be allocated from January 2017-December 2018.

Dr. David Bullock and Dr. Nicolas Martin received \$10,000 from the ACES Academy for Global Engagement, Partnerships for Global Impact program, for their application entitled "Data-intensive Fertilizer Management." This grant will be allocated from December 2017-December 2018.

Dr. David Bullock, K. Johansen, Krystal Montesdeoca, Laila Puntel, and Daniel Schreiber received \$50,000 from National Science Foundation Innovation Corps Program for their application, entitled, "Data-Intensive Farm Management." This grant will be allocated from October 2016-March 2018.

Pending Projects

Jayash Paudel and Dr. Christine Crago have submitted abstracts of two papers ("US Agricultural Adaptation to Climate Change: Implications for Fertilizer Use" and "Fertilizer Use and Water Quality in the United States") related to this project to several upcoming academic conferences: World Congress of Environmental and Resource Economists, Agricultural and Applied Economics Association annual meeting, Northeast Agricultural and Resource and Economics Association annual meeting.

Dr. David Bullock and Dr. Taro Mieno have submitted a paper, entitled "Assessing the Value of Informa-

tion from On-farm Field Trials” to the *American Journal of Agricultural Economics*.

Dr. David Bullock and Dr. Divina Gracia P. Rodriguez have submitted a paper, entitled “The Origins, Consequences, and Implications of Stanford’s ‘1.2’ Rule for Nitrogen Fertilizer Application” to *Applied Economics and Public Policy*.

Dr. Maria Boerngen and Mr. Benjamin Marks will be submitting a manuscript to a peer-reviewed journal in summer 2018. In addition, this work is serving as a pilot study for further research that will be conducted in collaboration with the Illinois Corn Growers Associa-

tion for a large-scale survey that will be distributed in Summer 2018 by Dr. Boerngen and George Hoselton, a graduate student who recently joined the DIFM project.

Dr. Boerngen and other DIFM collaborators are also planning to complete and submit multiple manuscripts in 2018.

Dr. Mengyu Guo, a recent postdoctoral researcher in Geography and GIScience on the DIFM project, is working on a project regarding the optimal means of performing trials using different sizes of equipment.

Other Presentations Related to this Project			
Authors	Title	Audience/Group	Date
Bullock, D.S., T. Mieno, and D.G. Bullock	On-farm Field Trials Using Precision Agriculture Technology	Oklahoma State University, Department of Agricultural Economics	January 20, 2017
Bullock, D.S., T. Mieno, and D.G. Bullock	A System for Data-Intensive Agricultural Research and Management	University of Illinois Agriculture Commercial Agricultural Workshop	February 15, 2017
Bullock, D.S., T. Josling, and K. Mitzezei	Agricultural Obstacles to a TTIP Agreement	Miami-Florida Jean Monnet Center of Excellence	February 19, 2017
Bullock, D.S., and T. Mieno	An Assessment of the Value of Information from On-farm Field Trials	NC-1034 Regional Meetings	February 24, 2017
Bullock, D.S., T. Mieno, and D.G. Bullock	On-farm Field Trials Using Precision Agriculture Technology	University of Nebraska Department of Agricultural Economics	March 21, 2017
Bullock, D.S.	Focused Big Data from Mass On-farm Experimentation	Illinois Big Data Summit in Food, Energy and Water	April 20, 2017
Bullock, D.S.	On-farm Field Trials Using Precision Agriculture Technology	Washington State University, Department of Crop and Soil Science	May 30, 2017
Bullock, D.S., L. Puntel, and A. Pagani	Métodos Intensivos en Datos para el Manejo de Nitrógeno en Maíz	Workshop: "Jornada Técnica de Agricultura de Presición"	July 19, 2017

Other Presentations Related to this Project			
Authors	Title	Audience/Group	Date
Bullock, D.S.	We Are Not in the Agricultural Information Age. But We Can Get There from Here	National Congress of the Brazilian Society of Rural Economy (SOBER) (Invited Plenary Speaker)	July 31, 2017
Bullock, D.S.	Data-intensive Farm Management: On-farm Field Trials Using Precision Agriculture Technology	Monsanto Commercial Group	August 28, 2017
Bullock, D.S.	Data-intensive Farm Management: On-farm Field Trials Using Precision Agriculture Technology	Agriculture and Consumer Economics Departmental Lightning Talk	September 1, 2017
Bullock, D.S.	The European Union's Common Agricultural Policy: Costs and Benefits of Membership	University of Illinois European Union Center Lecture Series	September 22, 2017
Bullock, D.S.	EU and US Agriculture, Agricultural Policy, An Agricultural Political Economy	Guest Lecture, EURO 501	October 5, 2017
Bullock, D.S.	Data-intensive Farm Management: On-farm Field Trials Using Precision Agriculture Technology	University of Illinois Data Science Day, Lightning Talk	October 10, 2017
Bullock, D.S., K. Mittenzwei, and T. Josling	Does More Public Transparency in Trade Negotiations Increase Social Welfare?	Agricultural Policy Research Conference (invited)	October 14, 2017
Bullock, D.S., and L. Puntel	Projecto: Manejo de Fertilización con Métodos Intensivos en Datos	IME Group Lecture	October 24, 2017
Bullock, D.S.	Some Thoughts on a Conceptual Framework and the Big Picture of On-Farm Precision Experimentation	Workshop to Plan and International Cyber-infrastructure for On-Farm Experiments Research	December 16, 2017



Extension Activities

During 2017, the DIFM project supported two educational programs currently managed within Nebraska Extension: the Precision Ag Data Management Workshops and the On Farm Research Network.

The Nebraska Extension Precision Ag Data Management Workshop

The goal of the Nebraska Extension Precision Ag Data Management Workshop is to teach producers how to better utilize data gathered from in-field operations as part of their management system. Utilizing data gathered from the DIFM project, a hands-on learning experience was provided to attendees to gain skills with applying economic data analysis techniques to variable-rate seeding and nitrogen application and harvest datasets.

Over 120 producers, advisors, crop consultants and other agricultural professionals attended the day-long workshops and completed the exercise which utilized the DIFM field site data. Producer acres represented at the workshops totaled nearly 180,000 acres while crop consultant/advisor acres exceeded 1 million acres. Feedback from the exercise was extremely positive and was one of the most popular learning experiences from the two-day workshops.

A majority of survey respondents (72%) indicated that they had gained significant knowledge regarding utilization of as-applied data and harvest data from variable-rate applications to conduct field-scale profitability analyses. In addition, a higher majority of respondents (86%) indicated that they would either adopt or continue using the techniques presented as a part of the learning experience. A large part of analysis related to this project.



Nebraska Extension On-Farm Research Meetings

Results from the DIFM Nebraska field sites were also presented at the 2017 Nebraska Extension On-Farm Research Meetings. The summaries included a discussion on how the project studies were developed and the field equipment used to conduct the field trials.

The total attendees at the On-Farm Research Meetings were 177, producers represented approximately 145,000 acres of crop production while consultant/advisor acres exceeded 2.3 million acres. Feedback from survey respondents was also positive regarding information they learned from these sessions, 65% indicated a moderate to significant gain in knowledge; while 62% indicated that they were somewhat likely to very likely to adopt or make changes to their operation based on the information presented.

Overall, extension efforts within Nebraska positively impacted agricultural professionals, exceeding 3.5 million crop production acres. Further deployment of materials and learning exercises online will provide future positive impacts beyond the state.

Budget Update

As of the writing of this report, we are completely on track with our funding. In years 1 and 2 of this grant, we were allotted approximately \$2.397 million. We have spent or encumbered \$1.824 million.

Faculty and Other Professionals

Funding for David Bullock, Luis Rodriguez, and Shaowen Wang has been expended or encumbered. We have spent nearly our expectation with **Grad Student Salary** funds.

We have not spent our complete allocation for a **Software Developer**. At present, we have about \$80,000, plus funds for fringe benefits, available for this position in our third and fourth year.

Additional funds from the late hiring of a **Nutrient Monitoring Technician** have been allocated to make the **Visiting Research Coordinator** position full-time.

We have spent \$20,000 more than our predicted funds on our **Field Monitoring Technician**, and intend to increase our budget for this position in the third and fourth year as we add additional fields. Funds for this position will come from unspent funds in **Services**.

Equipment and Travel

We overspent on **Equipment**, due to the unanticipated purchase of a Veris U3. However, the purchase of this piece of equipment was funded through the unspent **Sampling** budget, which would have otherwise paid for the cost of outside electroconductivity sampling.

Our **Travel** spending matched our budget.

Materials and Supplies, Publication Costs, Field Lab Maintenance, and Farmer Compensation

We have underspent on **Materials and Supplies** to date. Of the allotted \$38,000, we have spent \$10,092.

\$200,000 of the funding for **Field Lab Maintenance** has been expended or encumbered, as planned.

We have spent \$10,095 of the allotted \$31,500 on



Farmer Compensation to date. At minimum, we will spend \$9,500 on farmer compensation in year 2, when financial analysis is completed. We have additional funds available for farmer compensation if necessary, through Dr. Bullock's Office of International Programs budget, also earmarked to be used on field trials in this project.

Educational Expenses

We have underspent on **Educational Expenses**. We have spent \$28,255 of the allotted \$52,500 on undergraduate **Educational Program Stipends**. We hope to hire an additional student using these unused funds.

Indirect Costs

We have underspent on **Indirect Costs**. We have spent \$558,926 of the allotted \$709,290.

Subawards

We have underspent on **Subawards**. We were allocated \$415,858, and have spent \$250,516. Moving forward, we hope to spend funds previously allocated to the University of Kentucky to Montana State University, provided that we are able to bring that school on as a subawardee.

What Comes Next?

University of Illinois

Our goal in 2018 is to scale up! We are on track to complete 100 trials in 2018. As we continue to grow, we hope to find more efficient ways of data-gathering, cleaning, and analyzing; this will likely take the form of new software development. We are also recruiting a native Spanish-speaking undergraduate FAB Fellow, in keeping with our initial agreement with the USDA. Due to the Field Lab's calibration over the last year, 2018 will be the first year that we will be able to perform any significant nutrient loss monitoring on that trial field.

One significant challenge in this project is in the development of our decision support software. As a consequence of our changing relationship with the NCSA, our software development has not moved as quickly as we would have liked. This will be a major focus in the third year of the project.

We hope to add Montana State University as a subawardee to our grant for the next two years.

University of Nebraska

During the 2018 and 2019 growing seasons, Nebraska personnel will be responsible for five and six field sites, respectively. Data collected from these sites will be communicated with a broad range of agricultural professionals via Nebraska Extension programs. Based on past experience and results, producers engaged in such meetings will have a better understanding of opportunities to improve crop input use efficiency (particularly with nitrogen applications) to reduce environmental effects and increase profitability. Feedback from past participants has already shown the potential for such positive impacts related to this project.

University of Massachusetts, Amherst



David Bullock looks over field with a farmer in the Pacific Northwest.

Objective 1: Estimate the relationship between fertilizer use and water quality. We will refine preliminary estimates of the impact of changes in fertilizer use on water quality at the watershed level. We will present results of the analysis at various academic conferences, as well as collaborators on this NIFA grant. Based on feedback we receive, we may collect additional data or make changes to our analysis.

Objective 2: Examine the effect of climate change on fertilizer use, and its subsequent impact on water quality. We will continue data collection that will allow us to estimate the relationship between temperature and rainfall and fertilizer use by US farmers. Once data collection is complete, we conduct empirical analysis. The plan for the year is to complete the EVSI model for evaluating expected payoff from VAR and apply it for EC and other soil signals on data from as many project fields as possible from the first two years of experimental results.