Technical Proposal

Characterize physical and chemical properties of manure in California dairy systems to improve greenhouse gas (ghg) emission estimates

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Co-Investigators:

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Betsy Karle, UC Cooperative Extension, Glenn County Dairy Advisor
Dr. Zifei Liu, Assistant Professor, Biological and Agricultural Engineering, Kansas State University
Dr. Elizabeth Maga, Research Scientist, DAS
Dr. Wendy Powers, Professor, Director of Environmental Stewardship for Animal Agriculture Livestock Environmental Management, Michigan State University
Dr. Peter Robinson, Dairy Nutrition Specialist, DAS

Draft Proposal Prepared for:

California Air Resources Board Research Division

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Proposed research does not use human subjects

Table of Contents

CONTENTS

ABSTRACT.

This project responds to the current ARB research plan to **Characterize Physical and Chemical Properties of Manure in California Dairy Systems to Improve ghg Emission Estimates.**

The objectives of the project are to:

1. Analyze existing physical and chemical composition data on dairy lagoons as it relates to potential emissions of ghg. Determine which data may be used in ghg emissions calculations by ARB. Identify gaps in existing data and data needed by ARB.
2. Use previously discovered information on dietary composition and digestibility, dairy housing design, and facility manure flow to develop and deploy on-farm (n=6) survey of confinement and freestall facilities to quantify total and volatile solids (TS and VS) and N flows.
3. Perform microbial diversity and community metagenomics analysis of microbial populations present in liquids collected at different depths from wastewater storage ponds.
4. Use static chambers to analyze N_2O and CH_4 emissions from dairy lagoons.

Objective 1 is separated into 3 section. The first is to conduct a meta-analysis of existing data collected from dairy lagoons during the last two decades. These data were collected for other purposes. Chemical and physical composition of samples will be informative to ARB. The second component of this objective is to estimate liquid surface area of lagoons through calculations of Waste Management Plan information. The last component of this objective is to better understand ARB modeling parameters for ghg from manure management on dairies.

Objective 2 will quantify TS, VS, and N flows into and through 6 commercial dairies with detailed attention to both chemical and physical composition of lagoon contents (Redox, temperature, pH, TS, VS, DO, N fractions) and physical (particle size fractionation, temperature).

In Objective 3 we will prepare and analyze samples of lagoon contents for microbial diversity and community metagenomics analysis of microbial populations present in liquids collected at different depths from wastewater storage ponds. This will inform ARB if different populations (and end products of metabolism) of microbes exist at different depths of lagoons.

Objective 4 will be used to take air samples from static chambers on the lagoon surface to determine flux during 20 minute periods. This will provide farm specific data during different atmospheric conditions.

TECHNICAL PLAN

INTRODUCTION.

California has approximately 1.8 million dairy cows and additional associated replacement stock. For calculation purposes, we assume that cows lactate 305 days a year and are dry (non-lactating) 60 days a year. Average milk production in 2010 was 23,457 pounds per cow per year (CDFA, 2013).

ARB has relied on EPA generated information to develop greenhouse gas (ghg) emissions and estimate inventory contributions for various sectors in California. California's dairy cattle reside in an arid climate with animal management practices that are quite different from Wisconsin, New York or Florida. Manure management flows through facilities have been described (Meyer et al., 2011). Estimates for manure excretion can be made from modified excretion tables of ASABE (ASABE, 2005). Estimated daily total solids excretion per cow from this average production was 18.5 lbs with an assumed 85% of these as volatile solids (15.7 lbs per head per day while lactating). Estimated daily volatile solid excretion for dry cows was 9.2 lbs per head. Volatile solids excreted in a calendar year for milking animals is the sum of 305*15.7 and 60*9.2=5,340.5 lbs per milking animal per year (ASAE, 2005). Volatile solids contribution to the waste stream from replacement heifers statewide will be less than 40% of that produced by lactating animals (7.2 lbs per head per day for a 968 lb heifer).

Nitrogen excretion from an average lactating cow in California is less than 1 lb per head per day; markedly less than volatile solids, but sizeable. Nitrogen is excreted in feces and urine. When animals consume diets balanced to meet the National Research Council's Nutrient Requirements for Dairy Cattle 1989 protein composition, approximately 50% of excreted N is in feces and 50% is in urine. Fecal N composition is estimated as 97% organic and 3% ammoniacal. Urinary N is estimated as 55% urea and 45% other nitrogenous compounds (including purines and pyrimidines). Urea N collected in liquid waste streams will largely be hydrolyzed to ammoniacal N. This fraction of N may be volatilized, remain in solution, or be utilized by microbes in retention/treatment ponds. Urea excreted in open corrals may be hydrolyzed or may remain in the urea form depending on moisture conditions. Urea has been recovered in dry corral solids under summer conditions in the San Joaquin Valley (Meyer, unpublished).

Meyer has conducted a considerable number of sampling episodes on lagoons associated with dairies in the San Joaquin Valley. Many of these were conducted to quantify variability associated with sampling techniques and data collected would be informative to ARB in ghg modelling exercises. Other on-farm research has evaluated effectiveness of solid liquid separation systems (Meyer et al. 2003; Meyer et al., 2004), quantified water use associated with harvesting milk (Meyer et al., 2006), and analyzed chemical composition of manure from animals (Meyer et al., 2007).

Assembly Bill 32 mandates that California reduce its ghg emissions to 1990 levels by 2020 regardless of population or industrial growth, and further reduce emissions to 80% of these

levels by 2050. The California Air Resources Board developed and updates the Climate Change Scoping Plan to meet the 2020 goals. The Annual Research Plan for Fiscal Year 2015-2016 identified **Characterize Physical and Chemical Properties of Manure in California Dairy Systems to Improve ghg Emission Estimates** as an area for research efforts. This proposal is submitted in response to the current fiscal year research plan.

OBJECTIVES.

1. Analyze existing physical and chemical composition data on dairy lagoons as it relates to potential emissions of ghg. Determine which data may be used in ghg emissions calculations by ARB. Identify gaps in existing data and data needed by ARB.
2. Use previously discovered information on dietary composition and digestibility, dairy housing design, and facility manure flow to develop and deploy survey of confinement and freestall facilities to quantify total and volatile solids (TS and VS) flows.
3. Perform microbial diversity and community metagenomics analysis of microbial populations present in liquids collected at different depths from wastewater storage ponds.
4. Use static chambers to analyze N_2O and CH_4 emissions from dairy lagoons.

The results of these objectives will inform ARB to strengthen the scientific rigor in which ghg calculations are estimated from dairy operations in California.

PROJECT OBJECTIVES

WORKPLAN

Start date: July 1, 2015
End date: January 31, 2018

Task 1. July, 2015 to June, 2017

Analyze existing physical and chemical composition data from dairy lagoons as it relates to potential emissions of ghg. Determine which data may be used in ghg emissions calculations by ARB. Identify gaps in existing data and data needed by ARB. August 1 2015-

This Task focuses on analyses of previously collected data from California dairy lagoons to quantify reasonable ranges in chemical composition of dairy lagoon liquids related to potential ghg emissions. It incorporates both a paper analysis to determine range of exposed liquid surface area and a field survey to verify calculations for those dairies located in the Central Valley. A field survey will be utilized to estimate emitting surface area fluctuations for dairies located on the North Coast.

Task 1a. Analyze existing physical and chemical composition data on dairy lagoons as it relates to potential emissions of ghg. [Meyer data analyzed by Liu with input from team]

Analysis of existing data previously collected for other purposes from liquid storage structures and solid manure piles in California. Research team members have data from previously conducted research to quantify chemical and physical composition of effluent in liquid storage structures on commercial dairies in the San Joaquin Valley. Data were collected during various projects established to quantify variability in effluent composition and develop reasonable sampling protocols to estimate nutrient composition of liquid manure storage structures. One data set has results from samples taken at multiple locations and depths within storage lagoons and subsequent data from the effluent as it was irrigated within two weeks of lagoon sampling (3 to 4 samples retrieved for up to 10 days of irrigating). Parameters available in this set include N (total kjeldahl and ammonium), P, K, electrical conductivity, TS and VS. One freestall and one open lot dairy were included in the study. Another data set focused on variability of chemical and physical composition of lagoon samples from different locations and depths within ponds on 9 San Joaquin County dairies. Parameters available include TS, VS, redox, pH, temperature. A third data set contains temperature data from probes submersed in an anaerobic lagoon utilized in collecting biogas. These probes were submersed at different heights of the structure. Some chemical compositional data exist. A separate data set includes results of analysis of influent and effluent samples associated with various solid separation devices (mechanical separators, settling basins, weeping wall analysis). In addition to nutrient concentration of influent and effluent samples much of the data in this set also has particle size fractionation through a wet sieve apparatus.

Task 1b. Survey dairy facilities to quantify temporal change in exposed surface area as depth of liquid storage structures varies. [Heguy, Karle, Meyer to do analysis for team review]

A total of 45 randomly selected Waste Management Plans from Tulare, northern San Joaquin Valley Counties and Glenn/Tehama Counties will be analyzed to quantify exposed surface area during different times of the year. Farm survey data will be collected on 15 total facilities (n=5 in each geographic area) to verify assumptions used in analysis of certified plans. Additionally 5 dairies in the Sonoma/Marin area and 5 in Humboldt/Del Norte area will be surveyed to quantify differences in storage structure surface area characteristics during the year.

Task 1c. Determine which data may be used in ghg emissions calculations by ARB. [Team]

Discussion with ARB staff will occur to inform how current analyses are being conducted for ghg calculations. Compare base assumptions of model inputs to information obtained in Tasks 1a and 1b and identify where gaps exist.

Deliverables: Summary information on variability of chemical and physical composition of liquid manure. Summary information to identify if current ARB methods for calculating ghg are best suited for the diversity of manure collection systems located on California dairies.

Task 2. July, 2015 to June, 2017

Use previously discovered information on dietary composition and digestibility, dairy housing design, and facility manure flow to develop and deploy survey of confinement open lot and freestall facilities to quantify TS and VS flows. [Robinson, Meyer, Heguy, Karle and Team]

The research project will meet the main objectives of obtaining farm specific information on total and volatile solids (TS and VS) excretion and flow through common dairy housing systems to liquid and solid storage/treatment structures. The project is designed to utilize existing data collected for other purposes to identify gaps in understanding chemical and physical composition of waste streams as well as quantities present. Results will inform ARB modeling efforts and improve precision of these estimates. Research findings will fill knowledge gaps.

Analysis of dairy (facility and cow numbers) distribution within the San Joaquin Valley will be conducted to determine distribution of facilities/animals in open lot and freestall systems. Six dairies (selected proportional to animal distribution in San Joaquin Valley) will be used to collect detailed information on estimates of TS, VS, pH, Redox, temperature, organic N, ammonium N and nitrate N excreted from animals or in liquid waste stream and traversing the solid and liquid manure collection, treatment and storage systems. Facilities enrolled in the project will undergo a thorough analysis on feed information to estimate excretion of TS, VS and N. Monthly herd visits will be used to observe animal and manure management activities. Quarterly analysis of waste stream flows will be utilized to estimate TS, VS, and N flows into and through the system. Detailed lagoon monitoring (exposed surface area, sampling at the surface and various depth increments) will be used to collect samples for chemical (redox, temperature pH, TS, VS, DO) and physical (particle size fractionation, temperature) analysis and to preserve samples for Task 3 analyses. Field analysis (redox, pH, temperature, DO) will be conducted with appropriate analytical probes and calibrated according to manufacturer's specifications. Laboratory analysis will be conducted by commercial laboratories in California identified as acceptable for compliance with the Central Valley Regional Water Quality Control Board's General Order for Existing Milk Cow Dairies.

Deliverables: **Distribution of animals by housing type. TS, VS and N component flow through commercial dairies.**

Task 3. January, 2016 to May, 2017

Perform microbial diversity and community metagenomics analysis of microbial populations present in liquids collected at different depths from wastewater storage ponds. [Meyer, Heguy, Karle to retrieve samples; Maga to prepare and analyze samples].

150 Samples from Task 2 will be preserved for identification of the microbial communities present and their putative functions. Molecular-based techniques, now used to define microbial communities, are based on use of high-throughput, next generation sequencing (NGS) technology to identify the bacterial species present based on their DNA sequence. With this

approach, microbial diversity can be surveyed to a much greater depth and sensitivity than with culture-based methodologies. NGS allows for determination of the relative abundance of each bacterial species in the microbial population (phylogenetic diversity) and further sequencing can determine which genes are present in the population (metagenome). The metagenomic data can then be used to infer what functions the bacteria are performing. Knowledge of community structure and function will enlighten our understanding of microbial community variability, what types of pathways the bacteria are contributing to and byproducts they are producing.

Samples will be stored in small collection cups or sealed vials and preserved immediately on ice for transportation to UC Davis. Samples will be stored at -20 °C and processed to extract bacterial DNA; the DNA prepared for sequence analysis and then submitted to the UC Davis Genome Center for next generation sequencing. Once microbial diversity is known, a subset of grab samples will be submitted for metagenome analysis. The latter analysis will take 4-6 weeks to generate the sequence data and approximately 3 months for data analysis.

Deliverables:

Microbial diversity and metagenomic analysis results will be the first of its kind for liquid wastewater retrieved from cattle on commercial dairies in California.

Task 4. January, 2016 to June, 2017

Use static chambers to analyze N_2O and CH_4 emissions from dairy lagoons. [Powers and Team]

Static chambers will be built and deployed on pond surfaces associated with Task 2 to capture gas and collect grab samples at time 0 and 5 minute increments (total 5 samples per chamber per sampling event)for 20 minutes. Samples will be shipped to Michigan for analysis. Dr. Powers will provide chambers and sample collection and storage containers. 200 samples will collected for this task. Dr. Powers has appropriate analytical facilities that have been used for previous research projects.

Deliverables: ghg flux values from liquid storage structures.

DATA MANAGEMENT PLAN

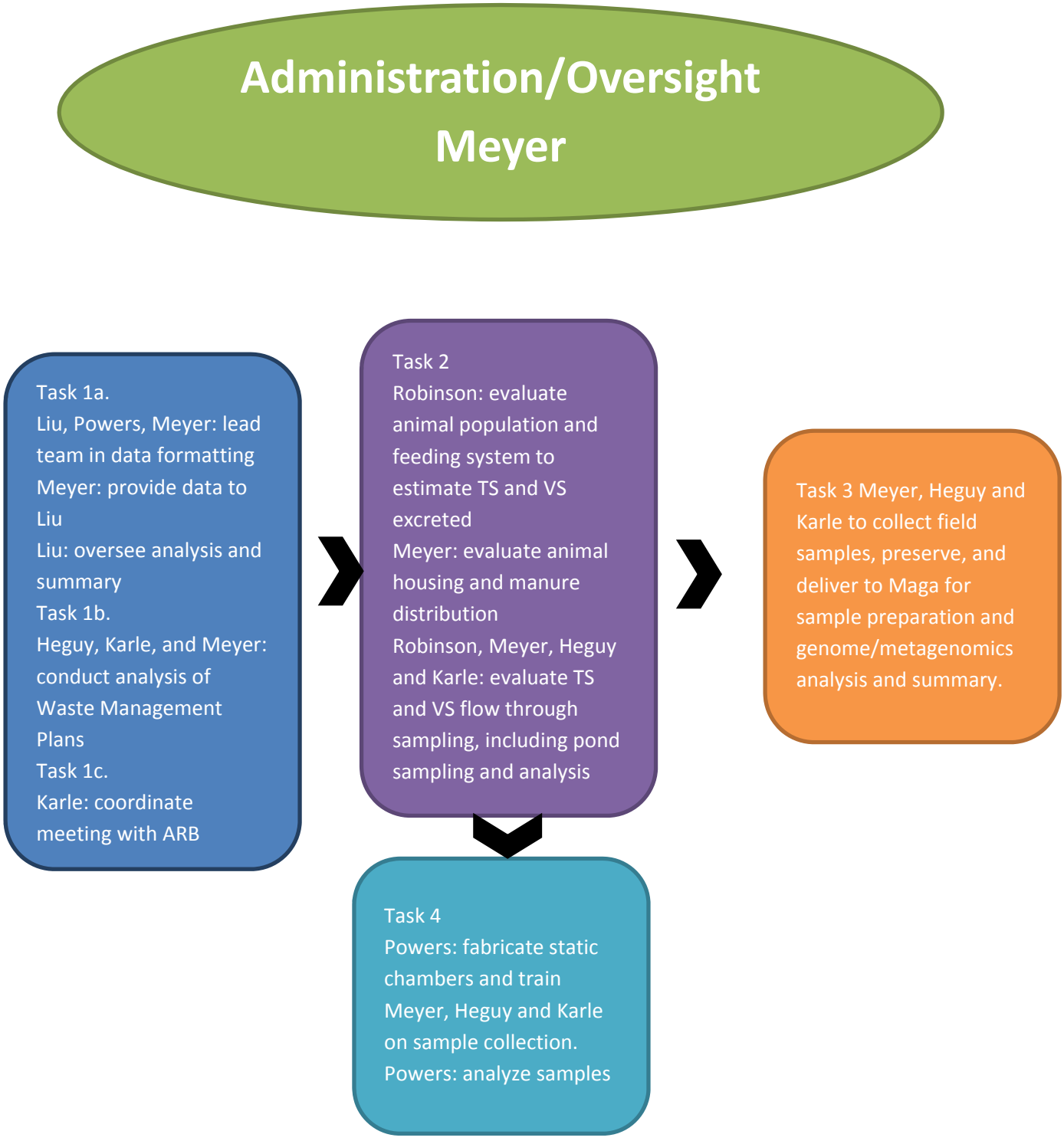
Field data collected for this project will be recorded on field sheets. Data will be transferred to database for analysis. Audits of data will be conducted to ensure correct entry of data with any values more than a deviation from the mean rechecked for correctness. Laboratory results will be received electronically. Data collected for this project are to establish survey results and will undergo standard statistical analyses (range, mean, mode, and standard deviation).

PROJECT SCHEDULE BY MONTH

Month >	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Task	**2015**						**2016**												**2017**											
1																														
2																														
3																														
4																														
Reports				**Q**			**Q**			**Q**			**Q**			**Q**			**Q**			**Q**			**DF**					**F**

Q = Quarterly progress report
DF = Deliver draft final report (to be submitted 6 months prior to contract expiration)
F = Deliver final report

PROJECT MANAGEMENT PLAN



THE PRINCIPAL INVESTIGATORS

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ACCEPTED RESPONSIBILITIES

UC Dairy Advisors Jennifer Heguy and Betsy Karle will provide assistance and leadership in identifying potential cooperators for Tasks 2 and 3 and providing physical assistance in collecting samples and obtaining measurements relative to these tasks. They will participate in discussions related to Tasks 1 and 4.

Dr. Elizabeth Maga will prepare and analyze samples obtained for Task 3 and provide analysis of metagenomic analyses.

Dr. Deanne Meyer will assume administrative responsibilities, maintain communications with cooperating investigators, funding agency representatives, and conduct on-farm evaluation of waste stream flows. She will provide data for analysis by Dr. Liu.

Dr. Powers will participate in discussions related to Tasks 1, 2, and 4. She will provide leadership for interpretation of waste stream TS and VS flows and impacts on ghg emissions estimates. She will work with Drs Liu and Meyer to facilitate completion of Task 1. She will oversee sampling protocols and sample analysis for Task 4.

Dr. Robinson will participate in discussions related to Tasks 1, 2, and 4. He will provide leadership in Task 2 and for analysis of dietary ingredient use and diet composition to estimate TS and VS excretion of animal groups.

Dr. Zifei Liu will work with Drs. Power and Meyer to establish formatting needed for database. He will conduct meta-analysis on previously collected data. He will participate in discussions associated with Tasks 1, 2, and 4.

PROJECT MANAGEMENT AND COORDINATION

Dr. Meyer will convene conference calls, meetings and/or email exchanges with all project principals as needed. She will also convene needed calls with ARB staff.

RELATED RESEARCH

Most PIs are employed by the University of California and have extensive collective knowledge of management on San Joaquin Valley dairies and dairy cattle nutrition and waste management in general. All but Dr. Maga work directly or indirectly with staff from Air and Water Regulatory agencies related to dairy facility management. Drs. Powers and Liu are employed by Michigan State and Kansas State Universities, respectively. Dr. Meyer has collaborated with them on previous work quantifying ghg emissions from different formulated diets fed to lactating cattle. The PIs have extensive professional experience in successfully obtaining and analyzing samples and are uniquely qualified for this project.

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Meyer, D., J.P. Harner, E.E. Tooman, C. Collar. 2004. Evaluation of weeping wall efficiency of solid liquid separation. Applied engineering in Ag 20: 349-354.

Meyer, D., P.L. Price, H.A. Rossow, N. Silva-del-Rio, B. Karle, P.H. Robinson, E.J. DePeters, and J. Fadel. 2011. Survey of dairy housing and manure management practices in California.

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Meyer, D., B. Reed, C. Batchelder, I. Zallo, P.L. Ristow, G. Higginbotham, M. Arana, T. Shultz, D.D. Mullinax, J. Merriam. 2006. Water use and winter liquid storage needs at central valley dairy farms in California. Applied Eng. Ag. 22: 121-126.

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PRELIMINARY COST PROPOSAL

	Task 1	Task 2	Task 3	Task 4	
Salary					
Price (20%)	5,000	15,000		10,193	
Maga (23%)			24,229		
Benefits					
Price	2,623	7,869		5,347	
Maga			9,329		
Supplies					
fleet services vehicle use		9,750		15,000	
supplies Liu	2,500				
probes replacements		1,500			
Fabrication of static samplers				1,000	
Analysis of gas samples (200 @ $15 each)				3,000	
shipping samples for testing		1,250		1,250	
sampling supplies	1,000	5,000	1,000	7,500	
DNA analysis and metagenome testing			13,500		
analysis of dairy lagoon samples (TS, VS, N fractions)		5,000			
publication costs	2,500	2,500	1,000	2,500	
Travel					
Robinson 52 trips @ $750 ea.		33,750		5,250	
Meyer 52 trips @ $250		11,250		1,750	
Karle	1,000	1,000		1,000	
Heguy	1,000	1,000		1,000	
Powers site visits				8,000	
Liu site team meeting	4,000				
Professional society travel to present	4,000	4,000	1,500	4,000	
Overhead at 10%	2,362	9,887	5,056	6,679	
Graduate student Kansas	72,500				
Grad student Davis		31,250		31,250	
Total costs	98,485	140,006	55,614	104,719	**398,824**

PRINICIPAL INVESTIGATOR BIOGRAPHICAL SKETCHES

NAME: Heguy, Jennifer	POSITION TITLE: UCCE - Farm Advisor Merced, Stanislaus & San Joaquin Counties, CA

CONTACT INFORMATION

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EDUCATION/TRAINING

University of California, Davis	B.S.	2004	Animal Science
University of California, Davis	M.S.	2006	Animal Science

RESEARCH AND PROFESSIONAL EXPERIENCE

2004 – 2006	Teaching Assistant, Dept. of Animal Science, University of California, Davis, CA
2006 – 2008	Junior Specialist, Dept. of Animal Science – Ruminant Nutrition Laboratory, University of California, Davis, CA
2008 – Present	Farm Advisor –Merced, Stanislaus & San Joaquin Counties, University of California Cooperative Extension, CA

PROFESSIONAL SOCIETIES

2005	American Dairy Science Association (ADSA).
2009	American Registry of Professional Animal Scientist (ARPAS).

PEER REVIEWED PUBLICATIONS

Ledgerwood, D.L., E.J. DePeters, P.R. Robinson, S.J. Taylor, and **J.M. Heguy.** 2009. Assessment of a brown midrib (BMR) mutant gene on the nutritive value of sudangrass using in vitro and in vivo techniques. Anim. Feed Sci. Technol. 150: 207-222.

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EDUCATION

M.S. Agro-Ecology, University of California, Davis, 2003
B.S. Agricultural Systems and Environment, University of California, Davis, 1999.

SELECTED PROFESSIONAL EXPERIENCE

7-14 to Present	Area Dairy Advisor and County Director, University of California Cooperative Extension, Orland, CA
10-07 to 6-14	Dairy Program Representative. University of California Cooperative Extension, Orland, California.
9-01 to 4-03	Post Graduate Researcher, Department of Plant Sciences, University of California, Davis.
7-99 to 8-01	Post Graduate Researcher, University of California Veterinary Medicine Teaching & Research Center, Tulare, California.

AWARDS AND HONORS

California Farm Bureau- Young Farmers and Ranchers “Excellence in Agriculture” Award Recipient, 2012.

PROFESSIONAL/TECHNICAL PAPERS

E.R. Atwill, M.L. Partyka, R.F. Bond, X. Li, C. Xiou, B.M. Karle. 2012. Introduction to Waterborne Pathogens in Agricultural Watersheds- Second Edition. USDA-NRCS Nutrient Management Technical Note No. 9.

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PEER-REVIEWED RESEARCH PUBLICATIONS

Meyer, D., P.L. Price, H.A. Rossow, N. Silva del Rio, B.M. Karle, P.H. Robinson, E.J. DePeters, J.G. Fadel. 2011. Survey of dairy housing and manure management practices in California. Journal of Dairy Science. 94:4744-4750.

Harter, T., E.R. Atwill, L. Hou. B.M. Karle, K.W. Tate. 2008. Developing risk models of Cryptosporidium transport in soils from vegetated, tilted soil box experiments. Journal of Environmental Quality. 37:245–258

Lewis, D.J., E.R. Atwill, M. S. Lennox, L. Hou, B. Karle, and K.W. Tate. 2005. Linking On-Farm Dairy Management Practices to Storm-Flow Fecal Coliform Loading for California Coastal Watersheds. Environmental Monitoring and Assessment. 107:407-425.

Lile, D.F., K.W. Tate, D.L. Lancaster, and B.M. Karle. 2003. Stubble Height Standards for Sierra Nevada Meadows can be Difficult to Meet. California Agriculture. 57:60-64.

Atwill, E.R., L. Hou, B.M. Karle, T. Harter, K.W. Tate, R.A. Dahlgren. 2002. Transport of *Cryptosporidium parvum* Oocysts through Vegetated Buffer Strips and Estimated Filtration Efficiency. Applied and Environmental Microbiology. 68:5517-5527.

RESEARCH AND EXTENSION GRANTS

Chigerwe, M. and B.M. Karle. 2015. Prevalence of failure of colostral passive immunity and associated colostral management practices in dairy heifer calves raised on organic dairies in California. University of California, Davis- Center for Food Animal Health. $20,000.

Karle, B.M. and D.M. Lightle. 2015. Soil health training for sustainable agriculture systems in the Northern Sacramento Valley. Western SARE Professional Development Program for California. $3,500.

Darby, H, J. Heemstra, C.A Daley, B.M. Karle. 2012-2016. goCrop™: Integration of Mobile Technology to Enhance Nutrient Management Implementation. USDA National Integrated Water Quality program. $394,000.

Daley, C.A, H. Darby, B.M. Karle. 2010-2013. Utility of the eOrganic web tools for technology transfer in organic dairy production.California State University Agricultural Research Initiative. $180,068.

Tate, K.W., E.R. Atwill, and B.M. Karle. 2000-2003. Developing a Warner Springs Ranch Grazing Management Plan to Protect a Municipal Drinking Water Reservoir. Vista Irrigation District. *$45,000*.

PROFESSIONAL CONFERENCE ABSTRACTS

Karle, B.M, W.J. Love, T. Lehenbauer, A.L. Van Eenennaam, L. Hulbert, R. J. Anderson, P. H. Kass, T. B. Farver, and S.S. Aly. 2014. A Survey of Calf Rearing Practices on California Dairies. American Association of Bovine Practioners. Albuquerque, NM.

Davy, J.S., B.M. Karle, and G.B. Kyser. 2014. Broadleaf weed control in irrigated pastures. Abstract for 2014 California Weed Science Society annual conference, Monterey, CA. January 22-24, 2014

B.M. Karle, M.A. Payne, P.L. Price, S.R. Ostrowski, D. Meyer. 2013. Medications and Treatment Practices Used on California Dairies: A Survey of Veterinarians. American Association of Bovine Practioners. Milwaukee, WI.

Heguy, J., B. Karle, D. Meyer. 2010. Calculating field nutrient removal rates to comply with the General Order for Existing Milk Cow Dairies in California's Central Valley. American Dairy Science Association. Denver, CO.

Atwill, E.R., L. Hou, B.M. Karle, T. Harter, K.W. Tate, and R.A. Dahlgren. 2001. Engineering Vegetative Buffer Strips for the Removal of Amphixenotic *Cryptosporidium parvum* from Runoff of Dairies and Grazed Agricultural Land. International Life Sciences Institute and International Association for Food Protection Symposium on Food Microbiology. Minneapolis, MN.

Dr. Zifei Liu

Assistant Professor
Biological & Agricultural Engineering
Kansas State University
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Manhattan, KS 66506
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Email: Zifeiliu@ksu.edu

Education	• Ph.D.	North Carolina State University (NCSU) Biological & Agricultural Engineering Interdisciplinary Minor in statistics and GIS	Dec. 2009
	• M.S.	University of Cincinnati, Environmental Engineering	July, 2005
	• B.S.	Nanjing University, Atmospheric Science	July, 1992
Employment History	• Assistant Professor	Kansas State University	2012-present
	• Postdoctoral Research Associate	Michigan State University (MSU)	2010-2012
	• Research Assistant	North Carolina State University	2005-2009
	• Research Assistant	University of Cincinnati	2002-2005
	• Environmental Engineer	Environmental Monitoring Center of Anhui Province, China	1992-2002
	o Certified environmental Auditor (Part time)	Luhua Environmental Consulting Company, China	2001-2002
	o Visiting Scientist	Kochi Prefectural Environmental Research Center, Japan	1999-2000
	o Research Trainee	International Center for Environmental Technology Transfer, Japan	1999
Research Experience	• Principal Investigator (PI): "Mitigation of Air Emissions from Swine Buildings through the Photocatalytic Technology Using UV/TiO_2", funded by National Pork Board. • PI: "Effectiveness of vegetative environmental buffers to reduce swine facility emissions", funded by National Pork Board.		

- PI: "Meta-analysis of H_2S, NH_3, VOC, PM_{10} and $PM_{2.5}$ emissions from swine productions in North America", funded by National Pork Board.
- PI: "Meta-analysis of greenhouse gas emissions from swine operations", funded by National Pork Board.
- Analyzed data and wrote up findings for studies assessing dietary strategies to mitigate air emissions from animal operations (including dairy cows, steers, swine, turkeys, broilers, and laying hens); involved in studies on emissions from composting of swine mortality.
- Conducted invited literature review on effect of dietary synthetic amino acids in US type swine diets on excretion and greenhouse gas emissions for Ajinomoto Inc.
- Developed an ammonia emission model for broiler chicken operations (Ph.D. dissertation).
- Worked as a major team member in setting up a mobile lab and performed routine monitoring tasks at a local farm for the National Air Emissions Monitoring Study.
- Participated in a National Research Initiative Competitive Grant project that aimed to characterize PM and gas pollutants at source and in the vicinity of a layer hen farm.
- Conducted research characterizing gaseous and particulate diesel emissions (M.S. thesis).
- Completed environmental impact assessment projects in a wide variety of industries as a project manager.

Grants

Role	Project title	Funding Agency	Status
PI	Mitigation of Air Emissions from Swine Buildings through the Photocatalytic Technology Using UV/TiO_2	National Pork Board	Funded $37,368
PI	Effectiveness of vegetative environmental buffers to reduce swine facility emissions	National Pork Board	Funded $36,262
Co-PI	Effects of Electrostatic Particle Ionization on Hog Barn Air Quality and Pig Growth Performance	KCARE	Funded $12,000
PI	Meta-analysis of H_2S, NH_3, VOC, PM_{10} and $PM_{2.5}$ emissions from swine productions in North America	National Pork Board	Funded $35,565
PI	Meta-analysis of greenhouse gas emissions from swine operations	National Pork Board	Funded $29,555

Peer Reviewed Journal Publications

- **Liu, Z,** J. Wang, Y. Liu, J. P. Murphy, R. Maghirang. 2015. Improving estimation of enteric methane emissions from dairy and beef cattle: a meta-analysis. *J. Anim. Sci.* In revision.
- **Liu, Z.,** W. Powers, and J. Harmon. 2015. Estimating ventilation rates of animal houses through CO_2 balance. Trans. ASABE. Submitted and under review.
- **Liu, Z.**, J. P. Murphy, R. Maghirang, and D. Devlin. 2015. Health and environmental impacts of smoke from vegetation fires: a review. Trans. ASABE. Submitted and under review.
- Wang-Li, L., Q. Li, **Z. Liu**, S. Shah, R.K.m. Jayanty, P. Bloomfield. 2014. Major Ionic Compositions of Fine Particulate Matter in an Animal Feeding Operation Facility and its Vicinity. *J. Air Waste Manag. Assoc.* 64(11):1279-87.
- **Liu, Z.,** W. Powers, and S. Mukhtar. 2014. A review of practices and technologies for odor control in swine production facilities. Appl. Eng. Agric. 30(3):477-492.
- **Liu, Z.** and W. Powers. 2014. Greenhouse gases emissions from multi-species animal operations and the potential diet effects. Trans. ASABE. 57(1).

- **Liu, Z.,** W. Powers, J. Murphy, and R. Maghirang. 2014. Ammonia and hydrogen sulfide emissions from swine production facilities in North America: a meta-analysis. J. Anim. Sci. 92: 1656-1665.
- **Liu, Z.,** W. Powers, and H. Liu. 2013. Greenhouse Gas Emissions from Swine Operations: Evaluation of the IPCC Approaches through Meta-analysis. *J. Anim. Sci.* 91(8):4017-4032.
- Wang-Li, L., Z. Cao, Q. Li, **Z. Liu**, D. Beasley. 2013. Concentration and particle size distribution of particulate matter inside tunnel-ventilated high-rise layer operation houses. *Atmos. Environ*. 66:8-16.
- **Liu, Z**., W. Powers, B. Oldick, J. Dadivson, and D. Meyer. 2012. Gas emissions from dairy cows fed typical diets of Midwest, South and West regions of the United States. *J. Environ. Qual.* 41(4):1228-1227.
- **Liu, Z**., W. Powers, D. Karcher, R. Angel, and T. J. Applegate. 2011. Effect of amino acid formulation and supplementation on nutrient balance in turkeys. *Poul. Sci*. 90:1153-1161.
- **Liu, Z**., L. Wang, D. B. Beasley, and S.B. Shah. 2011. Validation and uncertainty analysis of an ammonia emission model for broiler litter. *Trans. ASABE*. 54(3): 1051-1057.
- **Liu, Z**., W. Powers, D. Karcher, R. Angel, and T. J. Applegate. 2011. Effect of amino acid formulation and supplementation on air emissions from turkeys. *Trans. ASABE*. 54(2): 617-628.
- Li, Q., L. Wang-Li, **Z. Liu**, A. J. Heber. 2012. Field evaluation of particulate matter measurements using tapered element oscillating microbalance in a poultry house, *J. Air Waste Manag. Assoc.* 62(3):322-335.
- Wang, L., E.O. Oviedo-Rondón, J. Small, **Z. Liu**, B.W. Sheldon, G.B. Havenstein, and M.C. Williams. 2010. Farm-scale evaluation of ozonation for mitigating ammonia concentrations in broiler houses. *J. Air Waste Manag. Assoc*. 60(7): 789-96.
- **Liu, Z**., L. Wang, D. B. Beasley, and S.B. Shah. 2009. Modeling ammonia emissions from broiler litter at laboratory scale. *Trans. ASABE*, 52(5): 1683-1694.
- Li, Q., L. Wang, **Z. Liu**, and R. Kamens. 2009. Could ozonation technology really work for mitigating air emissions from animal feeding operations? *J. Air Waste Manag. Assoc*. 59: 1239-1246.
- **Liu, Z**., L. Wang, D.B. Beasley, 2008. Comparison of three techniques for determining ammonia emission fluxes from broiler litter. *Trans. ASABE,* 51(5): 1783-1790.
- **Liu, Z.,** L. Wang, D.B. Beasley, and E. Oviedo. 2007. Effect of moisture content on ammonia emissions from broiler litter: a laboratory study. *J. Atmos. Chem.* 58:41-53.
- **Liu, Z**., M. Lu, M.E. Birch, T.C. Keener, S. Kang, F. Liang, 2005. Variation of the particulate carbon distribution in emissions from a non-road diesel generator. *Environ. Sci. Technol.*, 39(20): 7840-7844.
- Liang, F., M. Lu, M. E. Birch, T. Keener, and **Z. Liu.** 2006. Determination of polycyclic aromatic sulfur heterocycles in diesel particulate matter and diesel fuel by gas chromatography with atomic emission detection", *J. Chromatography A*, 1114 (1): 145-153.

	• Liang, F., M. Lu, T.C. Keener and **Z. Liu**. 2005. The organic composition of diesel particulate matter, diesel fuel, and engine oil of a non-road diesel generator, *J. Environ. Monit.* 7: 983-988.
Co-authored book chapter	• Powers, W., **Z. Liu**, and V. Vaddella. 2013. Climate vulnerabilities of the poultry industry. In: Climate Vulnerability. Elsevier. Oxford, UK • Powers, W., V. Vaddella, and **Z. Liu**. 201x. Technical Working Group on Agricultural Greenhouse Gases: Swine chapter. Subcontract to Duke University (Prime contractor: Packard Foundation). In process.
Extension publication	• **Liu, Z.** 2014. Gas emissions from beef and dairy operations. Kansas State University Agricultural Experiment Station and Cooperative Extension Service. MF3185. • **Liu, Z.** 2014. Anaerobic digestion of livestock manure: feasibility and factors to consider. Kansas State University Agricultural Experiment Station and Cooperative Extension Service. MF3184. • **Liu, Z.** 2014. Carbon footprint of livestock production. Kansas State University Agricultural Experiment Station and Cooperative Extension Service. MF3180. • **Liu, Z.** 2014. Health guidelines for smoke from vegetation fires. Kansas State University Agricultural Experiment Station and Cooperative Extension Service. MF3179. • **Liu, Z**., W. Powers, and J. DeRouchey. 2013. Technologies for odor and air emission control in swine production facilities. Kansas State University Agricultural Experiment Station and Cooperative Extension Service. MF2918. • **Liu, Z**., C. Blocksome, and D. Devlin. 2013. Understanding air quality concerns of prescribed range burning in Kansas. Kansas State University Agricultural Experiment Station and Cooperative Extension Service. MF3121. • **Liu, Z.** and W. Powers. 2013. Ammonia and hydrogen sulfide emissions from swine production facilities in North America: a meta-analysis. Swine Industry Day Report of Progress, Kansas State University. • **Liu, Z.** and W. Powers. 2012. How much my farm emit? Michigan State University Extension. Emerging issues in animal agriculture.
Conference Papers and Presentations	• **Liu, Z**. Mitigation of air emissions from swine buildings through the photocatalytic technology using UV/TiO_2. Annual conference of Air & Waste Management Association. Extended Abstract # 33489. Long Beach, CA, June 24-27, 2014. Oral presentation. • **Liu, Z**. and W. Powers. Emissions of NH_3, H_2S, VOC, PM_{10} and $PM_{2.5}$ from swine production facilities in North America: a meta-analysis. ASABE paper No.1594405. Kansas City, MO, July 21-24, 2013. Oral presentation. • **Liu, Z**., R. Maghirang, and P. Murphy. Vegetative environmental buffers for mitigating air emissions from livestock facilities. Presented in the "From Waste to Worth" national conference, Denver, CO. April 1-5, 2013. Oral presentation. • **Liu, Z.** Air emission from swine production" in the Pork Checkoff Swine Education In-Service, Cincinnati, OH, September 25-27, 2012. Oral presentation. • **Liu, Z**., W. Powers, H. Liu. Meta-analysis of greenhouse gas emissions from swine Manure Land Application. ASABE paper No.121338478. Dallas, TX, July.29-Aug. 1, 2012. Oral presentation.

- **Liu, Z**., W. Powers, H. Liu. Meta-analysis of greenhouse gas emissions from swine operations. ASABE paper No.1111369. Louisville, KY, Aug.7-10, 2011. Oral presentation.
- **Liu, Z**., W. Powers, J. Harmon. CO_2 balance and estimation of ventilation rates in animal studies. ASABE paper No.1110880. Louisville, KY, Aug. 7-10, 2011. Poster presentation.
- **Liu, Z**. and W. Powers. Diet effects on greenhouse gases emissions from animal operations, AWMA Symposium on Air Quality Measurement Methods and Technology, Extended Abstract # 51. Los Angeles, CA. Nov.2-4, 2010. Oral presentation.
- **Liu, Z**., L. Wang, D. B. Beasley, and S.B. Shah. Validation and uncertainty analysis of an ammonia emission model for broiler litter. ASABE paper No. 096414. Reno, Nevada, June 20-24, 2009. Oral presentation.
- **Liu, Z**., L. Wang, Q. Li, and D. B. Beasley. Response of PM characteristics to NH_3 and other gaseous emission at a southeast layer operation. ASABE paper No. 096416. Reno, Nevada, June 20-24, 2009. Oral presentation.
- **Liu, Z**., L. Wang, D. B. Beasley, and S.B. Shah. Mass transfer coefficient of ammonia emissions from broiler litter. ASABE paper No. 084368. Providence, RI. June 29-July 2, 2008. Oral presentation.
- **Liu, Z**., L. Wang, D. B. Beasley, and S.B. Shah. Modeling ammonia emissions from broiler litter with a dynamic flow-through chamber system. ASABE Paper No. 074090. Minneapolis, MN, June 17-20, 2007. Oral presentation.
- **Liu, Z**., L. Wang, and D. B. Beasley. A review of emission models of ammonia released from broiler houses. ASABE paper No. 064101. Portland, Oregon, July 9-12, 2006. Oral presentation.
- **Liu, Z.,** L. Wang, D.B. Beasley, and E. Oviedo. Effect of moisture content on ammonia emissions from broiler litter: a laboratory study. Workshop on Agricultural Air Quality: State of the science, Bolger conference center, Potomac, Maryland, USA, June 5-8, 2006. Poster presentation.
- **Liu, Z**., M. Lu, M.E. Birch, T.C. Keener, S. Kang, F. Liang. The sulfur speciation of diesel emissions from a non-road diesel generator, AWMA's 98th Annual Conference & Exhibition, Minneapolis, MN, June 21-24, 2005. Oral presentation.
- **Liu, Z**., M. Lu, M.E. Birch, T.C. Keener, S. Kang, F. Liang. Investigation of organic DPM sampling artifacts of a high-volume sampling system, the 23rd Annual AAAR Conference, Atlanta, GA, October 4-8, 2004. Presented by Dr. Lu.
- **Liu, Z**., M. Lu, M.E. Birch, T.C. Keener, S. Kang, F. Liang. The OC/EC distribution of non-road diesel machines under various loads, AWMA's 97th Annual Conference & Exhibition, Indianapolis, IN, June 22-25, 2004. Oral presentation.

Affiliations

- Committee member of multi-state project S1032 "Improving the Sustainability of Livestock and Poultry Production in the United States".
- Committee member of multi-state project NCCC-9 of MidWest Plan Service which focus on developing research and extension educational materials.
- Member of American Society of Agricultural and Biological Engineers (ASABE) / SE-305 Environment Air Quality committee.
- Association of Overseas Chinese Agricultural, Biological and Food Engineers (AOCABFE)
- Air & Waste Management Association (AWMA).
- Member of American Society for Engineering Education (ASEE).

Awards	• Boyd-Scott Graduate Research Award 3rd place, at ASABE, 2009 • Graduate Student Paper Competition Award 2nd place, from AOCABFE , 2007 • F.J. Hassler Graduate Fellowship, 2006 • Scarpino MS Thesis Award, 2005

NAME Elizabeth A. Maga	POSITION TITLE Adjunct Professor
eRA COMMONS USER NAME EAMAGA	

EDUCATION/TRAINING

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	YEAR(s)	FIELD OF STUDY
Colorado State University Fort Collins, CO	B.S.	1988	Chemical Engineering
University of California Davis, Davis, CA	Ph.D.	1994	Food Science & Technology
University of California Davis, Davis, CA	Post-Doc	1994-1996, 1997-1999	Animal Science

Personal Statement

The overall goal of my research program is to demonstrate that milk from genetically engineered dairy animals containing increased levels of protective antimicrobial proteins can be used to improve human health. More specifically, we have generated transgenic goats that express increased levels of human lysozyme, a key human milk component thought to be involved with the development of a health-promoting gut microbiota. My overarching hypothesis is that upon consumption, lysozyme-rich milk will cause a beneficial modulation of intestinal microbiota populations thereby resulting in improved intestinal and overall health. My work is both mechanistic and translational in nature by not only dissecting the role of gut microbiota on health, but also by translating the use of lysozyme-rich milk into an effective preventative or treatment agent against diarrheal illness. I have considerable experience with transgenic animals, using the pig as a model for studying human health and analysis of microbial populations using molecular techniques. I have been PI or coPI on multiple grants including federally-funded USDA NIFA grants to determine the safety of our line of genetically engineered goats as well as an award from the Bill and Melinda Gates foundation to test the ability of lysozyme-rich milk to mitigate the effects of malnutrition at the level of the intestine using a pig model. All have been successfully administered and produced peer-reviewed publications as well as collaborations. In summary, I have a record of novel and productive research using animal agriculture as a tool to improve human health and am well positioned to carry out the proposed research.

Positions and Honors

Positions and Employment

1994 - 1996 Postdoctoral Researcher, Department of Animal Science, University of California, Davis.

1996 - 1997 Staff Research Associate, Division of Nephrology, Department of Internal Medicine, University of California, Davis.

1997 - 1999 Senior Postdoctoral Researcher, Department of Animal Science, University of California, Davis.
1999 - 2007 Assistant Research Biologist, Department of Animal Science, University of California, Davis.
2003 - 2014 Lecturer, Department of Animal Science, University of California, Davis (Lactation and Animal Genetics)
2007 - 2014 Associate Research Biologist, Department of Animal Science, University of California, Davis.
2013 - 2014 Research Biologist, Department of Animal Science, University of California, Davis
2014 - Adjunct Professor, Department of Animal Science, University of California, Davis

Selected Peer-reviewed publications- last 5 years (from a list of 44 peer-reviewed publications)

1. Brundige, D. R., **Maga, E. A.**, Klasing, K. C. and Murray, J. D. 2010. Consumption of pasteurized human lysozyme transgenic goats' milk alters serum metabolite profile in young pigs. *Transgenic Res*. **19:**563-574.
2. Murray, J. D. and **Maga, E. A**. 2010. Is there a risk from not using GE animals? *Transgenic Res*. **19:**357-361.
3. Jackson, K. A., Berg, J. M., Murray, J. D. and **Maga, E. A**. 2010. Evaluating the fitness of human lysozyme transgenic dairy goats: Growth and reproductive traits. *Transgenic Res*. **19:**977-986.
4. **Maga, E. A.** and Murray, J. D. 2010. Welfare applications of genetically engineered animals for use in agriculture. *J. Anim. Sci.* **88:**1588-1591.
5. Fahrenkrug, S. C., Blake, A., Carlson, D. F., Doran, T., Van Eenennaam, A., Faber, D., Galli, C., Gao, Q., Hackett, P. B., Li, N., **Maga, E. A**., Muir, W. M., Murray, J. D., Shi, D., Stotish, R., Sullivan, E., Taylor, J. F., Walton, M., Wheeler, M., Whitelaw, B. and Glenn, B. P. 2010. Precision genetics for complex objectives in animal agriculture. *J. Anim. Sci*. **88:**2530-2539.
6. Cooper, C. A., Brundige, D. R., Reh, W. A., **Maga, E. A.** and Murray, J. D. 2011. Lysozyme transgenic goats' milk positively impacts intestinal cytokine expression and morphology. *Transgenic Res*. **20:**1235-1243.
7. **Maga, E. A.**, Desai, P. T., Weimer, B. C., Dao, N., Kültz, D. and Murray, J. D. 2012. Consumption of lysozyme-rich milk can alter microbial fecal populations. *Appl. Environ. Microbiol.* **78:**6153-6160.
8. Tavares, K.C. S., Pinho, R. M., Carneiro, I. S., Aguiar, L. H., Calderon, C. E. M., Martins, L. T., Ambrosio, C. E., **Maga, E. A.**, Bertolini, M., Murray, J. D. and Bertolini, L. R. 2012. Efficient RNAi-induced protein knockdown in somatic cells using diced or chemically produced small interfering RNAs (siRNA). *Acta Scientiae Veterinariae*. **40:**1048.
9. Carvalho, E. B., **Maga, E. A.**, Quetz, J. S., Lima, I. F. N., Magalhaes, H. Y. F., Rodrigues, F. A. R, Silva, A. V. A, Prata, M. M. G, Cavalcante, P. A., Havt, A., Bertolini, M., Bertolini, L. R. and Lima, A. A. M. 2012. Goat milk with and without increased concentrations of lysozyme improves repair of intestinal cell damage induced by enteroaggregative *Escherichia coli*. *BMC Gastroenterol.* **12:**106.
10. Koop, G., De Visscher, A., Collar, C. A., Bacon, D. A. C., **Maga, E. A.**, Murray, J. D., Supré, K., De Vliegher,S., Haesebrouck, F., Rowe, J. D., Nielen, M. and van Werven, T. 2012. Identification of coagulase-negative *Staphylococcus* species from goat milk with API staph

and with transfer RNA-intergenic spacer PCR combined with capillary electrophoresis. *J. Dairy Sci.* **95:**7200-7205.

11. Cooper, C. A., Nelson, K., **Maga, E. A.** and Murray, J. D. 2013. Consumption of transgenic cows' milk containing human lactoferrin results in beneficial changes in the gastrointestinal tract and systemic health of young pigs. *Transgenic Res.* **22:**571-578.
12. **Maga, E. A.**, Weimer, B. C. and Murray, J. D. 2013. Dissecting the role of milk components on gut microbiota composition. *Gut Microbes* **4:**136-139.
13. Cooper, C. A., Garas Klobas, L. C., **Maga, E. A.** and Murray, J. D. 2013. Consuming transgenic goats' milk containing the antimicrobial protein lysozyme helps resolve diarrhea in young pigs. PloS ONE 8:e58409.
14. Cooper, C. A., **Maga, E. A.** and Murray, J. D. 2014. Consumption of transgenic milk containing the antimicrobials lactoferrin and lysozyme separately and in conjunction by 6-week old pigs improves intestinal and systemic health. *J. Dairy Res.* **81:**30-37.
15. Clark, M., Murray, J. D. and **Maga, E. A.** 2014. Assessing unintended effects of a mammary-specific transgene at the whole animal level in host and non-target animals. *Transgenic Res.* **23:**245-256.
16. McInnis, E. A., Kalanetra, K. M., Mills, D. A. and **Maga, E. A.** 2014. Analysis of raw goat milk microbiota: Impact of stage of lactation and lysozyme on microbial diversity. *Food Microbiol*. In press.

Research Support- last 5 years

Ongoing

1. Biotechnology Risk Assessment Program (Maga) 9/1/10 - 8/31/14
   USDA National Institute of Food and Agriculture (NIFA): Whole Animal Assessment of Unintended Effects of Foreign Gene Products on Host and Non-Target Organisms

Completed

1. Phase I Grand Challenges Explorations (Maga) 11/1/12-4/30/14
   Bill and Melinda Gates Foundation: Preventing diarrhea with lysozyme-rich milk

2. Innovative Development Award Program (Maga) 7/1/12-6/30/14
   UC Davis Academic Federation Committee on Research: Lysozyme-rich milk as a potential therapy for inflammatory bowel diseases

3. Biotechnology Risk Assessment Research Grants Program 9/1/08 – 8/31/10
   USDA National Institute of Food and Agriculture (NIFA): Assessing the potential for transgene transformation of intestinal bacteria and non-transgenic animal intestinal epithelium

4. Competitive Grants Program 2005-01655 (Maga) 7/1/05-6/30/10
   USDA-NRI: Assessment of the Well-Being and Behavior of Genetically Engineered Dairy Goats

DEANNE MEYER
LIVESTOCK WASTE MANAGEMENT SPECIALIST
UNIVERSITY OF CALIFORNIA, DAVIS

EDUCATION:

Ph.D. August, 1989	University of Florida, Gainesville: Animal Science (Dairy Nutrition/Waste Management). Minors: Agricultural and Extension Education, and Farming Systems.
M.S. May, 1986	University of Florida, Gainesville: Dairy Science (Herd Health Record Analysis/Mastitis). Minor: Food and Resource Economics.
B.S. June, 1983	University of California, Davis. Animal Science.

EMPLOYMENT:

8/92 to current	Assistant/Associate/Specialist Livestock Waste Management (Extension 75%/Research 25%), University of California, Davis.
8/89 to 8/92	Extension Dairy Specialist (80%)/Assistant Professor (20%), North Dakota State University, Fargo.

RESEARCH AREAS:

Analyses of production, collection, storage, transportation, and utilization of manure management waste stream(s) on dairies. Research has focused on nutrient flows through dairy operations including: feed inventory management, salt accumulation, silage pile/face management, content of manure solids and liquids, milk parlor water use, efficiency of mechanical and gravity flow separator devices, analyses of other manure treatment technologies, nutrient distribution during land applications, and ammonia volatilization. Member: US EPA Scientific Advisory Board Panel on Animal Feeding Operation Emissions; numerous committees within California related to dairy manure; San Joaquin Air District Dairy Subcommittee of the Agricultural Technical Advisory Committee.

EXTENSION EFFORTS:

Serve as Module Coordinator for the California Dairy Quality Assurance Program's Environmental Stewardship module. Established the Environmental Stewardship Short Course I (1998). This six hour continuing education course provides updates for dairy operators related to manure management. Oversee development and delivery of outreach classes to dairy operators and consultants related to water in California's Central Valley and North Coast related to compliance with General Order of Waste Discharge Requirements or Conditional Waiver of Waste Discharge requirements. Curriculum developed with input and review from regulatory agency staff members and other partners in the California Dairy Quality Assurance Program. Curriculum development and dissemination also occurred and continues for compliance assistance with San Joaquin Air District Rule 4570 Phase II implementation.

Refereed and Peer Reviewed Articles and Book Chapters

Meyer, D. M., P. H. Robinson, P. L. Price and J. M. Heguy. 2015. Determination of silage face surface area on commercial California dairy farms. Grass and Forage Science. doi: 10.1111/gfs.12160.

Aly, S. S., H. A. Rossow, G. Acetoze, T. W Lehenbauer, M. Payne, D. Meyer, J. Maas, and B. Hoar. 2013. Survey of Beef Quality Assurance on California Dairies. J. Dairy Sci. 97:1348–1357.

Harrison, J.H., R. White, V. Ishler, G. Erickson, A. Sutton, T. Applegate, B. Richert, T. Nennich, R. Koelsch, R. Burns, D. Meyer, R. Massey, G. Carpenter. 2012. Implementation of feed management as part of whole farm nutrient management. Professional Animal Scientist. In press.

Liu, Z., W. Powers, B. Oldick, J. Davidson, and D. Meyer. 2012. Gas Emissions from dairy cows fed typical diets of Midwest, south and west regions of the United States. J. Env. Qual. In press.

Council for Agricultural Science and Technology (CAST) (Zering, K.D., T.J. Centner, D.Meyer, G.L. Newton, J.M.Sweeten, S. Woodruff). 2012. Water and Land Issues Associated with Animal Agriculture: A U.S. Perspective. CAST Issue Paper 50, Ames, Iowa.

Meyer, D., P.L. Price, H.A. Rossow, N. Silva-del-Rio, B. Karle, P.H. Robinson, E.J. DePeters, and J. Fadel. 2011. Survey of dairy housing and manure management practices in California. J. Dairy Sci. 94: 4744-4750.

Meyer, D. and T. Powers Jr. 2011. Manure treatment technologies: anaerobic digesters. University of California Agriculture and Natural Resources. Publication 8409. http://anrcatalog.ucdavis.edu/pdf/8409.pdf.

Reganold, J.P., D. Jackson-Smith, S.S. Batie, R.R. Harwood, J.L. Kornegay, D. Bucks, C.B. Flora, J.C. Hanson, W.A. Jury, D. Meyer, A. Schumacher Jr., H. Sehmsdorf, C. Shennan, L.A. Thrupp, P. Willis. 2011. Transforming U.S. Agriculture. Science 332: 670-671.

Holstege, D, Price, P, Miller, RO, Meyer, D. 2010. University of California, Davis, California. California Analytical Methods Manual for Dairy General Order Compliance – Nutrient Management Plan Constituents. University of California, Davis Analytical Laboratory. http://anlab.ucdavis.edu/docs/uc_analytical_methods.pdf .

Robinson, P. and D. Meyer. 2011. Total mixed ration (TMR) sampling protocol. University of California Agriculture and Natural Resources. Publication 8413. http://anrcatalog.ucdavis.edu/pdf/8413.pdf.

Kornegay, J.,R. Harwood, S. Batie, D. Bucks, C. Flora, J. Hanson, D. Jackson-Smith, W. Jury, D. Meyer, J.P. Reganold, A. Schukacher, Jr., H. Sehmsdorf, C. Shennan, L.A. Thrupp, and P. Willis. 2010. Toward Sustainable Agricultural Systems in the 21st Century. Board on Agriculture and Natural Resources, National Research Council. National Academy Press. Washington, D.C. In press

Committee Participation (2010-current):

- US EPA Scientific Advisory Board Panel Animal Emissions.
- California Department of Food and Agriculture Anaerobic Digester Technical Advisory Panel. 2014 to current.
- California Department of Food and Agriculture Blue Ribbon Panel on Sustainability; subcommittee Scientific Advisory Panel to streamline regulatory requirements, 2011.
- California Biogas Regulatory Workgroup member--Department of Food and Agriculture, 2011.
- California Biogas Technology Workgroup member—Department of Food and Agriculture, 2011.
- Biogas California Energy Commission Project Advisory Committee: energy, economic,

and environmental performance of dairy bio-power and bio-methane systems. 2009-2012.

- Livestock and Poultry subcommittee responsible for white paper for USDA NRCS Agricultural Air Quality Task Force, Recommended Units and Supporting Data for Standardized Reporting of Air Emissions from Animal Agriculture. Paper presented Sept 21, 2010.
- National Academy of Science Sustainable Agriculture in the 21st Century.
- Regional Research Committee S-1032. ***Improving the Sustainability of Livestock and Poultry Production in the United States.***
- ***Central Valley Regional Water Quality Control Board Stakeholder Group for groundwater monitoring of dairy facilities. 2007 through present.***
- University of California's Committee of Experts (scientific information to Region 5 Water Quality Control Board) to provide science based information used in establishing water quality permit for Central Valley.
- Panel member Dairy Manure Technology Feasibility evaluation process with US EPA and California Air Resources Board. 2004-2005, 2008-2009.
- Co-chair of the subcommittee of the American Society of Agricultural Engineers responsible for modification of the dairy manure data in Standards Table D384.2 (Standard used by USDA Natural Resources Conservation Service and consulting engineers to estimate nutrient loads at livestock facilities).
- USDA NRI Air Quality Panel Manager: 2006, 2007, panel member 2009, 2010.
- USDA SBIR Soil/Water Panel member 2013; Manager Phase I and Phase II 2014, 2015.
- Federation of Animal Science Societies Environment and Watershed Committee (2004-2010).
- Representative to Western Dairy Management Conference Planning Committee (1998 to present)

Honors and Awards:

S-1032 Regional Research Group received. 2010 Experiment Station Section Excellence in Multistate Research Award.

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Education

- B.S., Animal Science, Cornell University, 1989
- M.S., Dairy Science, University of Florida, 1993
- Ph.D., Animal Science, University of Florida, 1997

Academic Appointments

- Assistant Professor, Animal Science, Iowa State University, 1997-2003.
- Courtesy Appointment, Ag & Bio Engineering, Iowa State University, 1999.
- Associate Professor, Animal Science, Iowa State University, 2003-2006.
- Director, Agriculture and Agribusiness Institute, Michigan State University Extension, 2010 – 2014.
- Director of Environmental Stewardship, Michigan State University, 2006-present.
- Professor, Animal Science and Biosystems & Agriculture Engineering, Michigan State University, 2006-present.
    - Current appointment: 60% extension / 40% research addressing environmental issues facing the livestock industry

Awards and Honors

- Iowa State University College of Agriculture Team Award, 1999
- ASAE Blue Ribbon Award, 2001
- American Dairy Science Association Production Foundation Scholar, 2002
- American Society of Animal Science Midwestern Section Young Extension Specialist Award, 2003
- ISU Foundation Young Extension Specialist Award, 2003
- Iowa Academy of Science Distinguished Scientist Award, 2004
- ASABE Standards Developer Award, 2006
- ASABE Presidential Citation for Service, 2006
- USDA Regional Project Nominee from Southern regional projects – National Excellence in Multistate Research Award. 2010. S-1032: Improving the sustainability of livestock and poultry production in the United States.

- USDA Regional Project – National Excellence in Multistate Research Award. 2011. Awarded to S-1032: Improving the sustainability of livestock and poultry production in the United States.

Memberships in Academic, Professional and Scholarly Societies

- American Dairy Science Association (ADSA)
- American Society of Animal Science (ASAS)
- American Society of Agricultural and Biological Engineers (ASABE)

EXCELLENCE IN DISCOVERY

Dr. Powers has integrated research discovery with outreach and implementation to provide the livestock industries with information and tools essential to their decision-making related to minimizing environmental impact while sustaining competitiveness and meeting challenges of growing demand for animal protein production coupled with changing and variable climate and natural resource limitations. Dr. Powers' research program compliments her Extension program by providing readily available research-based answers to environmental challenges on the farm. In particular, Dr. Powers' research program focuses on the impact of dietary strategies on nutrient excretions and air emissions.

RESEARCH PUBLICATIONS (INCLUDING THOSE WITH EXTENSION COMPONENT):

BOOK CHAPTERS

Lorimor, J., W. Powers and A. Sutton 2000. Manure characteristics. MWPS-18 Manure Management Systems Series. Midwest Plan Service, Ames, Iowa.

University of Iowa and Iowa State University. 2002. Iowa concentrated animal feeding operations air quality study. A peer-reviewed report submitted to Director Vonk, Iowa Department of Natural Resource. Developed at the request of Gov. Vilsack.

Van Horn, H.H. and W. J. Powers. 2003. Agricultural and environmental issues in the management of animal manures. In: Perspectives in world food and agriculture 2004, ed. C. G. Scanes and J.A. Miranowski. Iowa State Press, Ames, IA.

Iowa Department of Natural Resources. 2004. Animal feeding operations technical workgroup report on: air emissions characterization, dispersion modeling, and best management practices. http://www.iowadnr.com/air/afo/files/finalaforeport.pdf

American Society of Agriculture Engineers. 2005. Manure production and characteristics standard D384.2. American Society of Agricultural and Biological Engineers; St. Joseph, MI.

Meyer, D., J. Menke, W. Powers, and J. Harner, III. 2005. Dairy cattle: waste management. In: Encyclopedia of animal science. Marcel Dekker, Inc., New York.

Applegate, T. J., W. Powers, and R. Angel. 2007. Protein and amino acid nutrition in poultry: impacts on performance and the environment. In: Gaining the Edge in Pork and Poultry Production. Edit. J. A. Taylor-Pickard and P. Spring, Wageningen Academic Publishers, Wageningen, Netherlands. Pg. 139-151.

Powers, W., B. Auvermann, N. A. Cole, C. Gooch, R. Grant, J. Hatfield, P. Hunt, K. Johnson, A. Leytem, W. Liao, J. M. Powell. 2014. Chapter 5: Quantifying greenhouse gas sources and sinks in animal production systems. In: *Quantifying greenhouse gas*

fluxes in agriculture and forestry: methods for entity-scale inventory. Technical Bulletin 1939. Office of the Chief Economist, U.S. Department of Agriculture, Washington, D.C. 606 pages. M. Eve, D. Pape, M. Flugge, R. Steele, D. Man, M. Riley-Gilbert, and S. Biggar (Eds).

SELECTED REFEREED RESEARCH PAPERS

Hollman, M., W. Powers, A. Fogiel, N. Bello, J. Liesman, D. Beede. 2012. Enteric methane emissions and lactational performance of Holstein cows fed different concentrations of coconut oil. J. Dairy Sci. 95:2602-2615.

Li., W. and W. Powers. 2012. Effects of saponin extracts on air emissions from steers. J. Anim. Sci. 90:4001-4013.

Liu, Z., W. Powers., B. S. Oldick, J. A. Davidson, and D. Meyer. 2012. Air emissions from dairy cows fed typical diets of Midwest, South, and West U.S. J. Environ. Qual. 41(4):1228-1237.

Hollman, M., W. Powers, A. Fogiel, J. Liesman, D. Beede. 2013. Response profiles of enteric methane emissions and lactational performance during habituation to dietary coconut oil in dairy cows. J. Dairy Sci. 96:1769-1781.

Liu, Z., W. Powers, and H. Liu. 2013. Meta-analysis of greenhouse gas emissions from swine operations. J. Anim. Sci. 91:4017-4032.

Karcher, E. L., E. Wandschneider, and W. J. Powers. 2013. Emerging issues and sustainability in international agriculture: a study abroad program to Vietnam. NACTA 57:69 – 73.

Liu, Z. and W. Powers. 2013. Greenhouse gases emissions from multi-species animal operations and potential diet effects. Trans. of ASABE. 57(1):219-227.

Li., W., Q. Li, W. Powers, D. Karcher, C. R. Angel, and T. J. Applegate. 2014. Effects of distillers dried grains with solubles and mineral sources on gaseous emissions. J. Appl. Poult. Res. 23:41-50.

Liu, Z., W. Powers, P. Murphy, and R. Maghirang. 2014. Ammonia and hydrogen sulfide emissions from swine production facilities in North America: a meta-analysis. J. Anim. Sci. 92:1656-1665.

Liu, Z., W. Powers, and S. Mukhtar. 2014. A review of practices and technologies for odor control in swine production facilities. Appl. Engng. in Agric. 30(3):477-492.

Newbold, J. R., S. M. van Zijderveld, R. B. A. Hulshof, W. B. Fokkink, R. A. Leng, P. Terencio, W. J. Powers and H. B. Perdok. 2014. The effect of incremental levels of dietary nitrate on methane emissions in Holstein steers and performance in Nelore bulls. J. Anim Sci. 92:5032-5040.

Chiavegato, M. B., N. Palumbo and W. Powers. 2015. Ammonia and greenhouse gas emissions from housed Holstein steers fed different levels of dietary crude protein. J. Anim. Sci. 93(1):395-404.

Chiavegato, M. B., J. Rowntree, D. Carmichael, and W. Powers. 2014. Enteric methane from lactating beef cows. J. Anim. Sci. (in press, internet posting at doi:10.2527/jas.2014-8128).

Li, Q.-F, N. Trottier, W. Powers. 2014. Feeding Low Crude Protein Diets with Synthetic Amino Acids Supplementation to Reduce Air Emissions and the Carbon Footprint of Swine Production, Part 1: Gas Emissions from Housing. J. Anim. Sci. (in press for March publication, internet accessible at doi:10.2527/jas.2014-7746).

Chiavegato, M. B., J. Rowntree, D. Carmichael, and W. Powers. 2014. Pasture derived greenhouse gas emissions in cow-calf production systems. J. Anim. Sci. (in press for March publication, internet accessible at doi:10.2527/jas.2014-8134).
Liu, Z., J. Harmon and W. Powers. 2014. Estimating ventilation rates of animal houses through CO_2 balance. Trans. ASABE. (in press).

RESEARCH ABSTRACTS

Powers, W. Effect of feeding on air quality measures. 2010. Tri-State Dairy Nutrition Conference. Fort Wayne, IN. April 20-12, 2010.
Powers, W. 2010. Diet Impacts on Air Quality Measures. Eastern Nutrition Conference, Guelph, Ontario, May 12.
Powers, W. 2010. Feeding to meet current and pending air quality challenges". Penn State Dairy Workshop, Harrisburg, PA, November 11.
Powers, W. 2011. Managing Air Quality on the Dairy with the National Air Quality Site Assessment Tool (NAQSAT). Western Dairy Management Conference. Reno, NV. March 9-12, 2011.
Powers, W. 2011. Managing Air Quality on the Dairy with the National Air Quality Site Assessment Tool (NAQSAT). Western Dairy Air Quality Conference. Sacramento, CA. April 20-21, 2011.
Liu, Z. and W. Powers, and J. Harmon. 2011. CO2 Balance and Estimation of Ventilation Rates in Animal Studies. ASABE Paper No. 1110880. ASAE Annual International Meeting, Louisville, KY, Aug 7 – 10. St. Joseph, Mich.: ASABE.
Liu, Z. and W. Powers. 2011. Meta-analysis of greenhouse gas emissions from swine operations. ASABE Paper No. 1111369. ASAE Annual International Meeting, Louisville, KY, Aug 7 – 10. St. Joseph, Mich.: ASABE.
Vaddella, V., H. Liu, and W. Powers. 2012. Influence of Three Tannin Extracts Treatments on Air Emissions from Stored Steer Manure. Paper number 121338327. ASAE Annual International Meeting, Dallas, Texas, July 29 - August 1, 2012.
Liu, Z. and W. Powers. 2012. Meta-Analysis of Greenhouse Gas Emissions from Swine Manure Land Application. Paper number 121338478. ASAE Annual International Meeting, Dallas, Texas, July 29 - August 1, 2012.
Liu, Z. and W. Powers. 2013. Emissions of NH_3, H_2S, VOC, PM_{10} and $PM_{2.5}$ from swine production facilities in North America: a meta-analysis. Paper number 131594405, ASAE Annual International Meeting, Kansas City, Missouri, July 21 - July 24, 2013. St. Joseph, Mich.: ASABE.
Li, Q.-F., Y. Liu, W. Liao, W. Powers. 2014. Microalgae cultivation from animal production exhaust air: mitigate air emissions and recovery nutrients. Paper number 141904843. ASAE Annual International Meeting, Montreal, Quebec Canada July 13 to July 16, 2014. St. Joseph, Mich.: ASABE.

SELECTED COMMITTEES AND OTHER SERVICE

American Dairy Science Association (ADSA) representative for FASS *Environment, Waste Management, and Ecosystems* committee (1999-2007)

ADSA Advisory Council representative for the *Eighth International Symposium on Animal, Agricultural and Food Processing Wastes* (October 7-11, 2000)
Program committee for a National Symposium on "Addressing Animal Production/Waste Management Issues"
Iowa State University College of Agriculture CAFO response team; Chair Chapter 7 response
Iowa State University College of Agriculture/ University of Iowa Dept. of Public Health/ State of Iowa Air Quality Task Force
State of Iowa Nutrient Management Task Force
EPA Safe Harbor Monitoring Plan Committee
FASS DISCOVER Conference Chair (2006-2007)
USDA Agricultural Air Quality Task Force (2006 – 2008; 2008-2010)
Michigan Agriculture Environmental Assurance Program, co-chair (2007 - 2010)
Michigan Generally Accepted Site Selection and Odor Management Practices, Chair (2007 -)
Michigan Generally Accepted Manure Management Practices, Chair (2007 -2010); member (2007 – present)
MSUE Animal Agriculture and the Environment Area of Expertise Team, co-chair (2006 – 2008)
Guest lecturer for classes in Animal Science (1998 – 2012)
MSU College Promotion & Tenure Committee (2007 – 2010)
MSU Animal Science Departmental Advisory Committee (2007 – 2010)
US EPA Scientific Advisory Board (2011 – present)
Study Abroad Course co-instructor (2013, 2015) – course to Vietnam that includes undergraduates and Extension staff.

DR. PETER H. ROBINSON

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EDUCATION

Ph.D. Cornell University (Ithaca, NY) 1983 Dairy Cattle Nutrition
M.Sc. University of Guelph (Guelph, Canada) 1976 Animal Nutrition
B.Sc. University of Manitoba (Winnipeg, Canada) 1974 Animal Science

PROFESSIONAL EXPERIENCE

1997 to current: Cooperative Extension Specialist, Dairy Cattle Nutritionist
1989 through 1997: Dairy Cattle Research Scientist at the Fredericton Research Centre of Agriculture Canada in Fredericton Canada)
1986 through 1989: Research associate in the laboratory of Dr. J.J. Kennelly at the University of Alberta (Canada)
1985 through 1986: Research Bioscientist in the Health and Nutrition Division of Eastman Kodak in Rochester (NY)
1983 through 1985: Post-doctoral fellow in the laboratory of Dr. S. Tamminga at the Institute for Livestock Feeding and Nutrition Research (IVVO) in Lelystad (The Netherlands)
1976 through 1979: Beef and Dairy Specialist for Federated Co-operatives Limited in Saskatoon (Canada)

RESEARCH INTERESTS

Evaluation of the impact of dairy cattle feeding management strategies on production and environmental impacts. Specifically, my research has focused on protein and amino acid nutrition in dairy cows, methods to assess forage quality, and the effects of feeding on milk protein and fat levels and composition. My research has led to the development of feeding management models and on-farm tools to assist dairy farmers in improving performance while mitigating environmental impacts.

PROFESSIONAL ACTIVITIES

American Dairy Science Association - Member
Animal Feed Science and Technology - Co-editor-in-chief

SELECTED REFERENCES

McAllister, T.A., Beauchemin, K.A., McGinn, S.M., Hao, X., and **Robinson, P.H**. 2011. Preface: Greenhouse gases in animal agriculture – Finding a balance betwtween food production and missions. Anim. Feed Sci. Technol. 166/167: 1-6.

Robinson, P.H., Swanepoel, N., Shinzato, I., and Juchem, S.O. 2011. Productive responses of lactating dairy cattle to supplementing high levels of ruminally protected lysine using a rumen protection technology. Anim. Feed Sci. Technol, 168: 30-41.

Meyer, D., Price, P.L., Rossow, H.A., Silva-del-Rio, N., Karle, B.M., **Robinson, P.H.**, DePeters, E.J., and Fadel, J.G. 2011. Survey of dairy housing and manure management practices in California. J. Dairy Sci, 94: 4744-4750.

Swanepoel, N., **Robinson, P.H.**, Erasmus, L.J. 2010 . Amino acid needs of lactating dairy cows:

Predicting limiting amino acids in contemporary rations fed to high producing dairy cattle in California using metabolic models. Anim. Feed Sci. Technol, 161: 103-120.
Salem, A.Z.M., **Robinson, P.H.**, Lopez, S., Gohar, Y.M., Rojo, R., Tinoco, J.L. 2010. Sensitivity of sheep intestinal lactic acid bacteria to secondary compounds extracted from Acacia saligna leaves. Anim. Feed Sci. Technol, 161: 85-93.
Hernandez-Rivera, J.A., Alvarez-Valenzuela, F.D., Correa-Calderon, A., Macias-Cruz, U., Fadel, J.G., **Robinson, P.H.**, Avendano-Reyes, L. 2010. Effect of short-term cooling on physiological and productive responses of primiparous cows exposed to elevated ambient temperatures. Acta Agric. Scand. Section A, 61: 34-39.
Jackson, W., Krishnamoorthy, U., **Robinson, P.H.**, Fadel, J.G. 2010. Effect of changing partitioning factor (PF) and in vitro rate of gas production (k) of diets on intake and digestibility, microbial N production and composition, of lactating crossbred dairy cows. Anim. Feed Sci. Technol, 160: 128-136.
Krishnamoorthy, U., Robinson, P.H. 2010. Prediction of rumen microbial N supply in bovines from dietary values of partitioning factor (PF), in vitro rate of gas production (k), neutral detergent fibre and crude protein: A brief systematic review of studies completed in Bengaluru (India). Anim. Feed Sci. Technol, 160: 167-171.
Highstreet, A., **Robinson, P.H.**, Robison, J., Garrett, J.G. 2010. Response of Holstein cows to replacing urea a with a slowly rumen released urea in a diet high in soluble crude protein. Livest. Sci, 129: 179-185.
Marcillac-Embertson, N.M., **Robinson, P.H.**, Fadel, J.G., Mitloehner, F.M. 2009.
Effects of shade and sprinklers on performance, behavior, physiology, and the environment of heifers. J. Dairy Sci, 92: 506-517.
Shaw, S.L., Mitloehner, F.M., Jackson, W., DePeters, E.J., Fadel, J.G., **Robinson, P.H.**, Holzinger, R., and Goldstein, A.H. 2007. Volatile Organic Compound emissions from dairy cows and their waste as measured by proton-transfer-reaction mass spectroscopy. Environ. Sci. Technol, 41: 1310-1316.
Chang, A., Harter, T., Letey, J., Meyer, D., Meyer, R.D., Campbell-Mathews, M., Mitloehner, F., Pettygrove, S., **Robinson, P.H.**, and Zhang, R. 2007.Managing dairy manure in the central valley of California. University of California Agriculture and Natural Resources Publication 9004, Oakland, CA, 178.