Proposal #3

Proposal
Texas A&M AgriLife Research - Air Quality Research Program

Title: Developing a Functional Understanding of Greenhouse Gas Emissions from Beef Cattle Feedyards

PI: Dr. K. D. Casey, Associate Professor, Texas A&M AgriLife Research, Amarillo, TX.

Collaborators:

Dr. R. W. Todd, Research Scientist, USDA-ARS, Bushland, TX.

Dr. H. M. Waldrip, Research Scientist, USDA-ARS, Bushland, TX.

Amount Requested per year: $100,000 FY 2014 $100,000 FY 2015

Executive Summary

The research focus of this proposal is to continue to quantify and develop a mechanistic understanding of emissions of relevant greenhouse gas from beef cattle feedlots in the Southern Great Plains and to investigate the potential for and efficacy of mitigation approaches under feedyard conditions.

Nitrous oxide (N_2O) and methane (CH_4) are greenhouse gases that are emitted from feedlot facilities. Relative to carbon dioxide (CO_2), N_2O and CH_4 have global warming potentials (GWP) of 21 and 310 times that of CO_2 respectively. Little research has been conducted into the emissions of these greenhouse gases from beef cattle feedyards and particularly as it applies for the climatic conditions, ration formulations used and management practices of feedlots in the Texas High Plains.

In 2010, EPA issued the Mandatory Reporting of Greenhouse Gases Rule (74 FR 5620) which requires reporting of greenhouse gas (GHG) data and other relevant information from large sources and suppliers in the United States. Although, EPA is currently prevented from implementing the Mandatory GHG Reporting Rule subpart JJ (which applies to the manure management system at feedlots and other CAFOs) by Congressional action, it may do so in the future.

The Mandatory Reporting Rule requires only reporting of N_2O and CH_4 from the manure management system. Both inventories use the IPCC workbook methodologies as a basis for calculating emissions. While the calculated N_2O emissions are of lesser magnitude than CH_4, its much larger GWP means that N_2O is the dominant contributor to GHG emissions in terms of the reportable CO_2 equivalent.

This project will leverage considerable recent investment in GHG instrumentation, method development and data collected over the past two years to:

- Provide a quantitative understanding of the spatial and temporal variability of N_2O and CH_4 emissions from feedlots and their associated manure management systems, contributing to the development of process based models.
- Produce data that will be critical to the development of appropriate, scientifically based, emissions estimating methodologies and be suitable as input to national greenhouse gas emission inventories.
- Develop a demonstrated capability to investigate and quantify N_2O and CH_4 emissions from agricultural area sources including feedlots and their associated manure management systems. Once developed, this capability should be readily transferable to other agricultural area sources and attract external funding.

Deliverables: peer reviewed publications, data contributed to development of process based models and greenhouse gas emission inventories, competitive position for attracting external funding.

Proposal Narrative

Goals and objectives

The overall goal of the proposed project is to develop a mechanistic understanding of factors influencing the emissions of greenhouse gases from cattle feedyards in the Texas High Plains.

Specific Objectives:

1. Examine the magnitude, spatial and temporal variability of emissions of N_2O and CH_4 from the manure management system from cattle feedyards in the Texas High Plains using non-flow-through non-steady-state (NFT-NSS) chamber-based measurement techniques.
2. Develop a functional understanding of the environmental variables that influence and control the emissions of N_2O and CH_4 from the manure management system from cattle feedyards in the Texas High Plains. Contribute this data to the developers of larger scale, process based models to improve their predictive capability for the conditions prevailing on typical cattle feedyards in the Texas High Plains.
3. Investigate the performance of potential mitigation strategies including nitrification inhibitors and urease inhibitors on N_2O and CH_4 emissions from feedyard manure management system under controlled, laboratory scale conditions.

Strategies

We propose an approach involving:

- periodic measurement of the N_2O and CH_4 emission fluxes from selected areas within a number of feedlot facilities using NFT-NSS chambers. These studies will contribute source apportionment to the area integrated measurements and allow the development of a quantitative, mechanistic understanding of the emissions processes for individual manure management system components.
- Develop a measurement system that can be used to conduct detailed studies on cores collected from the feedyard pen and exposed to various treatments under controlled conditions.
- Strategic semi-continuous measurement of emission from cores collected from feedyards and exposed to treatments that allow us to hone in on the response mechanisms for environmental variables or investigate the potential efficacy of mitigation strategies.

Ongoing Research and Facilities

In late 2009, Dr Casey acquired a Varian 450 gas chromatograph equipped with detectors for N_2O, CH_4 and CO_2, and a Combi-PAL auto-sampler. During 2010, equipment for conducting NFT-NSS chamber studies was acquired and methodologies were developed for the application of this technique in feedlot and dry-lot dairy pens. Measurement of emission fluxes from manure management systems have been made at both feedlots and dairies for projects funded from USDA-NIFA, this Air Quality program. This capability is also routinely used to make measurements of GHG emissions from cropping systems under a separate USDA-NIFA grant. Figure 1 shows a NFT-NSS chamber deployed on a manure pack while figure 2 shows samples collected from the chambers being analyzed using the Varian 450 gas chromatograph.

Figure 1. NFT-NSS chamber deployed on manure pack at open-lot dairy

Figure 2. GHG samples being analyzed on Varian 450 gas chromatograph

The strong, rapid response in N_2O flux resulting from a 37 mm rainfall event is shown in figure 3. A pulse of N_2O is emitted from the manure pack while conditions are favorable for N_2O formation, however as manure pack quickly dries and conditions are no longer as favorable, the emission burst quickly declines to a baseline level over the next several days.

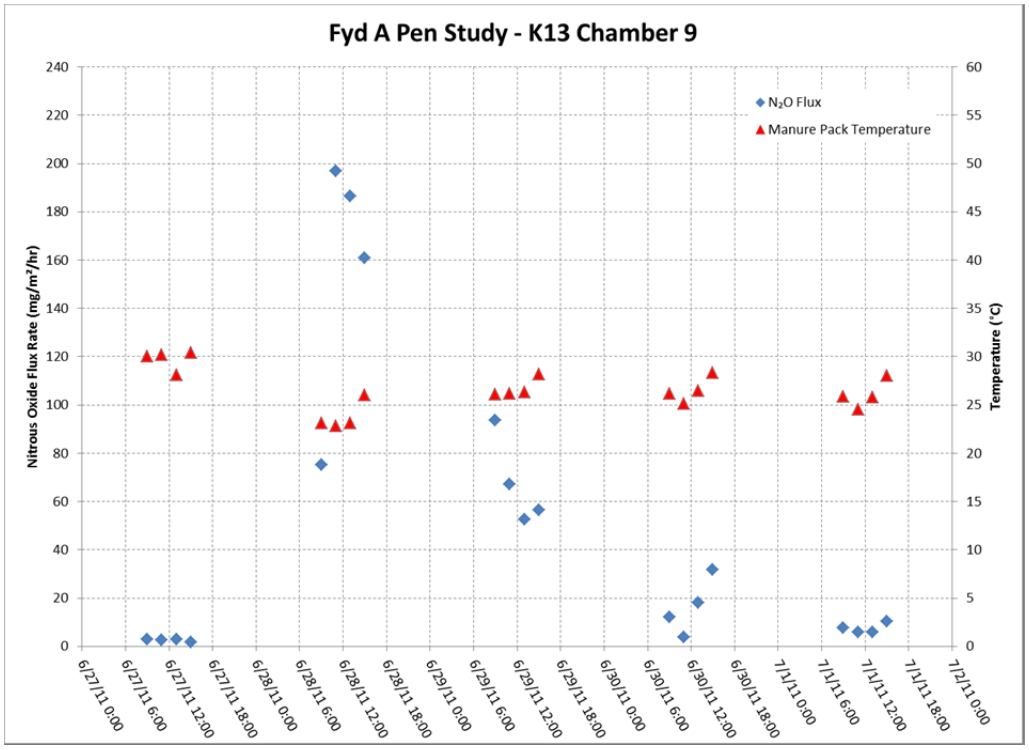

Figure 3. Figure shows results from intensive weeklong campaign at Fyd A where 37 mm of rain fell on the Monday night. Nitrous oxide emissions spiked next day but declined to near former levels by end of week.

The effect of increasing temperature on N_2O emissions is shown in figure 4. The increase in temperature between 08:00 and 14:00 CST each day corresponds with an increase in the N_2O flux rate. It can be seen from comparing the scales of figures 3 and 4, that the magnitude of the impact of a rainfall event on N_2O emissions is far greater than from the increase in temperature.

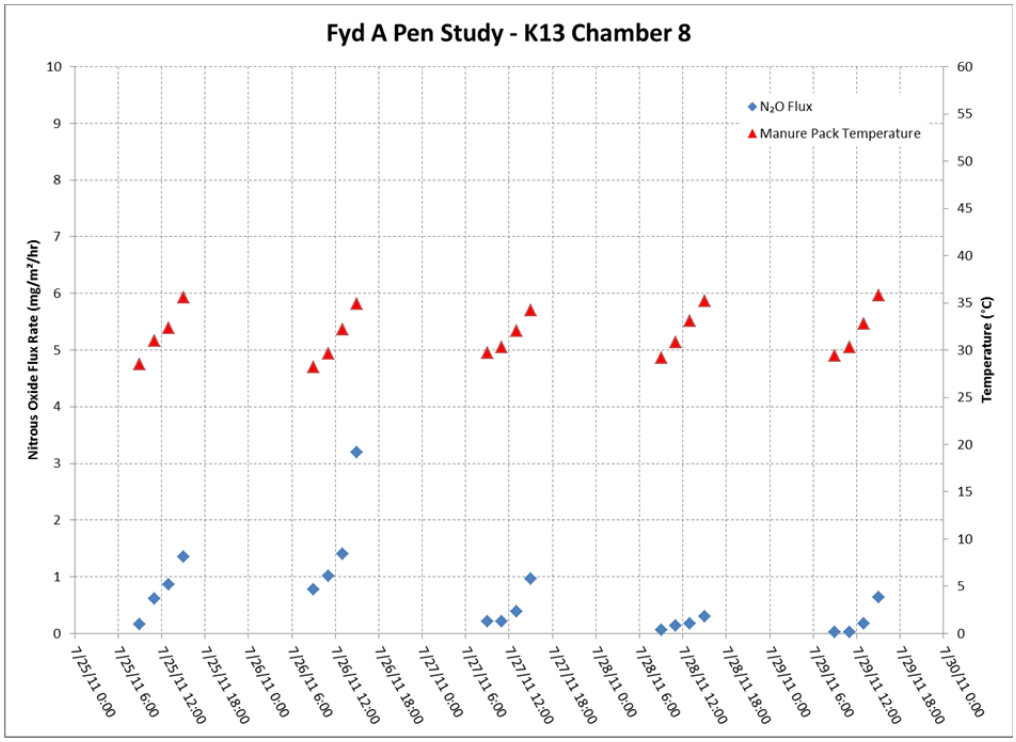

Figure 4. Figure shows results from intensive campaign at Fyd A under very dry summer conditions. Nitrous oxide emissions increases each day in response to increasing manure pack temperature.

An Innova 1312 Photoacoustic Multigas Analyzer is available to be used for making semi-continuous measurements of CO_2, CH4 and N_2O from collected cores under controlled laboratory conditions. A Thermo 55i analyzer is also available for making CH_4 measurements. An automated chamber system will need to be fabricated or purchased to enclose the core surface prior to each measurement cycle and a multiplexing system devised if concurrent measurements are to be made from more than one core.

Methodology

Measurements:

Strategic seasonal flux measurement campaigns from pen areas and other manure management system elements as accessable and appropriate will be made using NFT-NSS chambers. The recommendations of Rochette and Eriksen-Hamel (2008) and flux calculation methodology of Parkin and Venterea (2010) have been incorporated in our sampling and analysis protocols. Up to ten (10) chambers will be placed in a recently emptied pen and samples collected to enable determination of bi-hourly flux rates over a period of up to five (5) days. Appropriate environmental measurements will be made and manure samples collected for further analysis to enable characterization of the manure conditions.

Meteorological data will be collected using a 10 meter EPA-PSD class meteorological station situated on the predominant downwind edge of the feedyard.

Strategic semi-continuous emission measurements will be made from cores collected from feedyards and exposed to treatments that allow us to isolate the response mechanisms for selected environmental variables. This technique will also be used to investigate the performance of potential mitigation strategies including nitrification inhibitors and urease inhibitors on N_2O and CH_4 emissions under controlled, laboratory scale conditions.

Deliverables

1. A quantitative understanding of the spatial and temporal variability of N_2O and CH_4 emissions from feedlots and their associated manure management systems. This data will contribute to the development of process based models. Preliminary discussions have been held with the developers of the DNDC model regarding access to our data.
2. The data that will be produced by this research effort will be critical to the development of appropriate emissions estimating methodologies and be suitable as input to national greenhouse gas emission inventories.
3. Through this proposed research, we expect to develop a demonstrated capability to investigate and quantify N_2O and CH_4 emissions from agricultural area sources including feedlots and their associated manure management systems. Once developed, this capability should be readily transferable to other agricultural area sources.
4. Peer-reviewed manuscripts, abstracts and presentations.

Timeline

Activity	Year 1	Year 2
Project preparation and planning	**x**	
	x	**x**
Field data collection (NFT-NSS chamber studies)	**x**	**x**
Field data collection (Meteorological)	**x**	**x**
Develop instrumentation and methodology for controlled environment studies of collected cores	**x**	
Conduct controlled environment studies of collected cores with treatments of environmental conditions and/or potential mitigation strategies		**x**
Publication of results	**x**	**x**

Individual responsibilities

1) **Ken Casey, Ph.D. (Lead PI):** Dr Casey will be responsible for the overall project management, conduct of the field measurements using NFT-NSS chambers and operational maintenance meteorological stations. The proposed project will be carried out at feedyards on the Texas High Plains within approximately 50 miles from the Amarillo Research and Extension center.
2) **Rick Todd, Ph.D. and Heidi Waldrip, Ph.D. (Collaborators):** Drs Todd and Waldrip will collaborate on analysis of data from the field emission studies and on the conduct and analysis of the controlled environment studies. Drs Todd and Waldrip are contributing analytical capability to the current project to enhance shared improvements in the knowledge and understanding of emissions from waste management facilities.

Potential for Leveraging Resources (acquiring additional funding):

1) Success in previous leveraging of state funds by the PIs include:
    a. Impacts of biofuel induced land use change on energy, water, carbon and greenhouse gas balances of the Southwestern U.S. Cotton Belt region USDA-NIFA Sustainable Bioenergy -

Environmental Implications of Direct and Indirect Land Use Change (Total Funded: $499,930) [Rajan PI, Casey CoPI]., This project relies on sampling and analysis methodology, and analytical capability developed in part from funding obtained under this Air Quality program.

b. Monitoring and Mitigating Greenhouse Gas Emissions and Improving Nitrogen and Water Cycling through Beef Production Systems of the Great Plains: The Cattle Climate Center Coordinated Agricultural Project (Great Plains C3 CAP) USDA-NIFA-AFRI CAP (Total: $10,000,000 – Not Funded) [Casey CoPI]. A sub-project using NFT-NSS chamber measurements as developed under previous funding, was an important part of this proposal ($300,000). The fact that we had developed this capability, meant that we were included in this proposal.

2) Targeted future funding sources

The competitive funding environment has contracted under the on-going, politically driven, budget uncertainties. While nothing can be guaranteed, funding will be actively and aggressively pursued from funding agencies including:

- NIFA AFRI: The Agriculture and Natural Resources Science for Climate Variability and Change program, and the Foundation program have previously supported research on greenhouse gas emissions from agricultural production. Topic areas vary each year.
- NSF: The proposed project would generate a substantial data set that can be used to address some of the fundamental research questions in the Ecosystem Science division of NSF.
- EPA**:** Good collaborative relationships have been established by Dr Casey with scientists in the EPA National Risk Management Research Laboratory. Funding through the EPA-STAR program is a potential avenue; however topic areas vary each year and EPA's budget is under constant threat.

3) Plan for using requested funds as seed money for future grants:
The proposed research program will allow the PIs to generate preliminary data and refereed journal articles to support proposals to granting agencies that fund *fundamental, hypothesis-driven projects* (such as NSF) and those that fund *applied research projects* (such as EPA and USDA).

4) Budget:

Item	FY14	FY15
Salaries &Wages:		
Research Associates	38,500	40,500
Travel:		
Travel to feedyard sites (vehicle exp)	4,950	5,550
Conference Attendance	3,200	3,500
Material and Supplies:		
GC Calibration and consumable gases	7,400	7,400
NFT-NSS chamber supplies	7,100	7,100
Met Station maintenance	1,100	1,200
Innova: Calibration gases	4,800	5,000
Innova: Recalibration and Repairs	10,000	5,000
Construction of **s**ampling system for controlled environment studies	6,750	2,750
Consumables - controlled environment studies		3,600
Publication Costs	1,000	2,000
Other Direct Costs:		
GC maintenance contracts	12,000	13,000
Cellular data plans (Met Stns)	3,200	3,400
Annual Project Total	100,000	100,000

References:

Rochette, P. and N. S. Eriksen-Hamel. 2008. Chamber measurements of soil nitrous oxide flux: Are absolute values reliable? *Soil Science Society of America Journal* 72(2): 331-342.

Parkin, T. B., and R. T. Venterea. 2010. Chamber-based trace gas flux measurements. In USDA-ARS GRACEnet Sampling Protocols, 39. R. F. Follett, ed.

Interim Progress Report
Texas A&M AgriLife Research - Air Quality Research Program

Title: Baseline Inventory of Greenhouse Gas Emissions from Beef Cattle Feedyards

PI: Dr. K. D. Casey, Associate Professor, Texas A&M AgriLife Research, Amarillo, TX.

Co-PI: Dr. W.B. Faulkner, Research Assistant Professor, Texas A&M University, College Station, TX.

Collaborators: Dr. R. W. Todd, Research Scientist, USDA-ARS, Bushland, TX.

NFT-NSS Chambers Project Component

Key Outcomes

- A protocol for sample collection and analysis from feedlot pen areas was developed and implemented.
- Nine hundred and fifty flux measurements have been made at two feedyards over three measurement campaigns covering summer, spring and fall conditions. A further 100 measurements are planned for the July/August period of this project.
- Results showed the expected spatial and temporal variability within pens and were in the same range as those recorded by other investigators. Reflecting the prevailing dry conditions during the campaigns, many N_2O and CH_4 flux rate measurements were very low and towards to lower end of recorded ranges.
- Nitrous oxide and methane fluxes generally increased with increasing manure pack temperature – following a diurnal pattern. Nitrous oxide flux increase in response to was rainfall event is approximately 2 orders of magnitude greater than the diurnal temperature response.

Progress

- Between mid-July and mid-October 2011, four, one week long studies were at Texas Feedyards (2) Fyd A (3 weeks) and Fyd C (1 week), where 10, 20 cm dia, NFT-NSS flux chambers were used to measure N_2O, CH_4 and CO_2 emission fluxes from a newly vacated pen (650 flux measurements). Gas samples from the chambers were collected into evacuated vials for subsequent analysis by GC at 0, 10, 20 and 30 minutes after the chamber top was placed on the chamber base. During the first 3 of these studies, measurements were conducted at 8:00, 10:00 12:00 and 14:00 CST while the final study was only undertaken at 12:00 CST each day. Emission rates were calculated from the collected concentrations by fitting a quadratic equation to the concentration vs time relationship and solving for the slope at time 0. Under dry conditions, the N_2O flux was 0.3 – 1.2 mg/m^2/hr, whereas in the week in which a 37 mm rainfall event occurred after the first day of sampling, N_2O flux averaged 50.85 mg/m^2/hr. Nitrous oxide flux generally increases with increasing manure pack temperature – following a diurnal pattern. Following a rainfall event, nitrous oxide flux spikes followed by a decline to pre-event fluxes over 3 – 6 days. Nitrous oxide flux increase in response to was rainfall event is approximately 2 orders of magnitude greater than the diurnal temperature response. Weekly average CH_4 fluxes ranged from 0.1 – 7.35 mg/m^2/hr during these studies. Methane flux generally increases with increasing manure pack temperature – following a diurnal pattern.

- Between mid-October and mid-December 2012, four, one week long studies were at Fyd C (3 weeks) and Fyd A (1 week), where 10, 20 cm dia, NFT-NSS flux chambers were used to measure N_2O, CH_4 and CO_2 emission fluxes from a newly vacated pen (200 flux measurements). During each of these studies, measurements were conducted at 12:00 CST. Under dry conditions at Fyd C, the average weekly N_2O flux varied from 0.12 – 0.17 mg/m^2/hr, whereas at Fyd A was 11.65 mg/m^2/hr however this was biased high by one chamber which exhibited a very high emission flux (weekly average: 106.17 mg/m^2/hr). Under dry conditions at Fyd C, the weekly average CH_4 fluxes were 4.57 mg/m^2/hr (range: 1.17 – 9.97 mg/m^2/hr) during these studies.
- Between mid-March and early-May 2013, two, one week long studies were at Fyd C where 10, 20 cm dia, NFT-NSS flux chambers were used to measure N_2O, CH_4 and CO_2 emission fluxes from a newly vacated pen (100 flux measurements). During each of these studies, measurements were conducted at 12:00 CST. Under dry, cool conditions, the weekly average N_2O flux was 0.09 mg/m^2/hr (range: 0.01 – 0.17 mg/m^2/hr). The weekly CH_4 average fluxes were 5.78 mg/m^2/hr (range: 1.01 – 10.54 mg/m^2/hr) during these studies.

Publications

Casey, K. D., V. K. Vaddella, H.. Waldrip, R. W. Todd, W. B. Faulkner.. 2013. Greenhouse gas emissions from beef cattle feedlot surfaces in Texas during fall. ASABE Paper No. 13-1620819, St. Joseph, Mich.: ASABE. [Abstract & Poster]

Casey, K. D., V. K. Vaddella. 2013. Greenhouse gas emissions from pen surfaces at Texas High Plains beef feedyards during Fall. Proc. Greenhouse Gas in Animal Agriculture International Conf. Dublin, Ireland, June, 2013.

Casey, K. D., R. W. Todd, W. B. Faulkner, A. P. Caramanica. 2012. Nitrous oxide and methane emissions from beef cattle feedlot surfaces in Texas. ASABE Paper No 12-1337597, St. Joseph, Mich.: ASABE. [Abstract & Poster]

OP-FTIR Project Component

Key Outcomes

- Two bi-static Open-Path Fourier Transform Infrared (OP-FTIR) systems set up at a 50,000-head feedyard.
- Lessons learned from the initial deployment of the first OP-FTIR system were incorporated in the configuration and establishment of the second system
- Environmental conditions at a feedyard provides a very difficult operational environment for the OP-FTIR instrumentation resulting in data loss and high maintenance requirements.
- While much has been achieved in terms of developing a measurement system that will function reliably under field conditions and collect good data, much still remains to be achieved in demonstrating OP_FTIR as a robust technique for measuring GHG emissions from feedyards.

Progress

Two bi-static Open-Path Fourier Transform Infrared (OP-FTIR) systems (MIDAC, MA) have been set up and used to measure GHG concentrations downwind and upwind of a 50,000-head feedyard in the Texas

Panhandle with the goal of developing baseline greenhouse gas (GHG) emissions data from Texas cattle feeding operations. Many unforeseen challenges have arisen with regards to keeping both systems operational and analyzing the data from both system, most notably:

- Dust emissions from the feedyard regularly obscure the optics of the downwind system, requiring frequent cleaning to maintain a usable signal, and
- The graduate students working on the project both accepted full-time jobs during the project.

Therefore, the dataset is not as complete as desired, but some useful data have been collected that demonstrate the advantages of the system for near-continuous measurement, have allowed for development of data analysis algorithms and data management structures that will streamline analysis of future data, and have rendered sufficient emissions estimates to warrant continuation of concentration measurements.

Concentrations observed during August and September 2012 are shown in Table 1.

Table1: Downwind and upwind GHG concentrations during the summer.

Wind Direction		Methane (ppm)	Nitrous Oxide (ppb)
Downwind	Range	1.76 - 6.36	317 - 962
	Mean ± SD	3.20 ± 0.75	515 ± 116
Upwind	Range	1.70 - 11.14	310 - 451
	Mean ± SD	2.47 ± 0.71	357 ± 32

Based on two months' measurements of GHG concentrations (August and September 2012) that were used in the Windtrax® model to back-calculate emission rates, the average CH_4 and N_2O emissions during the summer were 45.68 ug/m^2/s and 14.56 ug/m^2/s, respectively. Figure 1 illustrates the pollutant wind rose for CH_4 emissions by wind direction. The majority of low CH_4 emissions are related to the winds coming from the North while higher CH_4 emissions are associated with the SW winds. Dispersion modeling of additional data is ongoing.

Publications

Hamilton, K. M., W. B. Faulkner, M. S. Borhan, and K. D. Casey, 2013, Evaluation of methods for characterizing greenhouse gas emissions from cattle feed yards. Trans ASABE [In preparation]

Gang Sun, William B. Faulkner, Kenneth D. Casey, Keith Hamilton, 2013, Quantifying long-term GHG emissions form large beef feedyards using an open-path spectroscopy monitoring system ASABE Paper No. 13-1622165, St. Joseph, Mich.: ASABE.

Hamilton, K. M., W. B. Faulkner, K. D. Casey, M. S. Borhan. 2011. Comparison of methods to measure greenhouse gas emissions from large area sources. ASABE Paper No. 1111529, St. Joseph, Mich.: ASABE. [Abstract & Poster]

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**** All sections except "Publications" must fit in 2 pages.***

Education and Training (Bachelors through PhD and post-doc information, in chronological order)

Institution	***Major/Area of Study***	***Degree***	***Year***
University of Southern Queensland	Agricultural Engineering	B.Eng.	1981
University of Southern Queensland	Information Processing	GradDipInfProc	1986
Clemson University	Agricultural Engineering	M.S.	2001
University of Kentucky	Biosystems and Agricultural Engineering	Ph.D.	2005

Research and Professional Experience (List appointments/positions in reverse-chronological order)

Year – Year	Title, Department, Institution
2011 - date	Associate Professor, Amarillo, Texas A&M AgriLife Research
2005 - 2011	Assistant Professor, Amarillo, Texas AgriLife Research
2001 - 2005	Research Associate, Biosystems and Agricultural Engineering, University of Kentucky
1995-2001	Principal Environmental Engineer, Department of Primary Industries, Queensland, Australia
1981-1995	Project leader/Agricultural Engineer, Department of Primary Industries, Queensland, Australia

Collaborators and Affiliations
Please refer to the Conflict of Interest list.

Synergistic Activities
Professional Organization Membership
Registered Professional Engineer Queensland (Registration No. 2922): 1990-present
American Society of Agricultural and Biological Engineers: 1980-present
American Society of Heating, refrigerating and Air Conditioning Engineers: 2004-present
Air & Waste Management Association: 2002-present
Clean Air Society of Australia and New Zealand: 1996-present

Public Service Activities
Review manuscripts for:

Transactions of the ASABE/ASAE	annually
Journal of Applied Engineering in Agriculture	annually
Journal of the Air & Waste Management Association	annually
Biosystems Engineering	periodically
Journal of Environmental Quality	periodically

Review research proposals for:
USDA Small Business Innovation Research (SBIR) 2009, 2011

Committee Membership:
Multistate Research Project S1025 – Systems for controlling Air Pollutant Emissions and Indoor Environments of Poultry, Swine and Dairy Facilities.

Member since 2006.
Vice Chairman – 2008
Chairman – 2009, 2010

American Society of Agricultural and Biological Engineers

SE-305 Environmental Air Quality committee member since 2002
Session SE-12a&b - Session Organizer, 2007, 2008, 2009, 2010, 2011, 2012
SE-402 Beef Facilities committee member since 2012
SE-405 Poultry Housing committee member since 2002, chair 2004-2005

Awards

- Pig Research and Development Corporation Scholarship to undertake Master of Science degree at Clemson University, South Carolina, USA. [1991]
- Vice Chancellor's Award in Excellence – Member of a Research Team "Air Quality: Reducing Feedlot Emissions Team" [2008]
- Texas Environmental Excellence Awards: Agriculture –Finalist (Project Team Member) [2009]
- Texas Environmental Excellence Awards: Agriculture –Winner (Project Team Member) [2010]
- Federal Laboratory Consortium for Technology Transfer, Mid Continent Region: Notable Technology Development –Winner (Project Team Member) [2010]

Publications
(All publications in refereed journals during the past 4 years, including those in press. Also, non-refereed technical papers with relevance to the project.)

Parker, D., J. Ham, B. Woodbury, L. Cai, M. Spiehs, M. Rhoades, S. Trabue, K. Casey, R. Todd, and A. Cole. 2013. Standardization of Flux Chamber and Wind Tunnel Flux Measurements for Quantifying Emissions from Area Sources. *Atmospheric Environment* 66: 72-83.

Casey, K. D., R. W. Todd, W. B. Faulkner, A. P. Caramanica. 2012. Nitrous oxide and methane emissions from beef cattle feedlot surfaces in Texas. ASABE Paper No. 12-1337597, St. Joseph, Mich.: ASABE.

Todd, R. W., N. A. Cole, D. B. Parker, M. B. Rhoades, and K. D. Casey. 2011. Daily, monthly, seasonal and annual ammonia emissions from southern High Plains cattle feedyards. *Journal of Environmental Quality* 40(4): 1090-1095.

Todd, R. W., N. A. Cole, K. D. Casey, R. Hagevoort, and B. W. Auvermann. 2011. Methane emissions from southern High Plains dairy wastewater lagoons in summer. *Animal Feed Science and Technology.* 166-167: 575-580.

Hamilton, K. M., W. B. Faulkner, K. D. Casey, M. S. Borhan. 2011. Comparison of methods to measure greenhouse gas emissions from large area sources. ASABE Paper No. 1111529, St. Joseph, Mich.: ASABE.

Casey, K. D., R. S. Gates, R. C. Shores, E. D. Thoma, and D. B. Harris. 2010. Ammonia emissions from a U.S. broiler house – Comparison of concurrent measurements using three different technologies. *Journal of the Air & Waste Management Association* 60(8): 939-948.

Parker, D. B., E. A. Caraway, M. B. Rhoades, N. A. Cole, R. W. Todd, and K. D. Casey. 2010. Effect of wind tunnel air velocity on VOC flux from standard solutions and CAFO manure/wastewater. *Transactions of ASABE* 53(3): 831-845.

Gates, R. S., K. D. Casey, H. Xin, and R. T. Burns. 2009. Building emissions uncertainty estimates. *Transactions of the ASABE* 52(4): 1345-1351.

Singh, A., K. D. Casey, W. D. King, A. J. Pescatore, R. S. Gates and M. J. Ford. 2009. Efficacy of urease inhibitor to reduce ammonia emission from poultry houses. *Journal of Applied Poultry Research* 18(1): 34-42.

Casey, K. D., R. S. Gates, E. F. Wheeler, H. Xin, Y. Liang, A. J. Pescatore, and M. J. Ford. 2008. On-farm fan performance: Implications for ventilation and operating cost. *Journal of Applied Poultry Research* 17(2): 283-295.

Gates, R. S., K. D. Casey, E. F. Wheeler, H. Xin and A. J. Pescatore. 2008. U.S. broiler ammonia emissions inventory. *Atmospheric Environment* 42(14): 3342-3350.

Topper, P. A., E. F. Wheeler, J. S. Zajaczkowski, R. S. Gates, H. Xin, Y. Liang, and K. D. Casey. 2008. Ammonia emissions from two empty broiler houses with built-up litter. *Transactions of the ASABE* 51(1): 215-225.

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**** All sections except "Publications" must fit in 2 pages.***

Education and Training

Institution	***Major/Area of Study***	***Degree***	***Year***
University of Nebraska-Lincoln	Botany	B.S.	1979
University of Nebraska-Lincoln	Agronomy	Ph.D.	1996
USDA-ARS	Plant Physiologist	post-doc	1997-1999

Research and Professional Experience

Year – Year	Title, Department, Institution
1999-present	Research Soil Scientist; Renewable Energy and Manure Management Research Unit, USDA-ARS Conservation and Production Research Laboratory, Bushland, TX
1997-1999	Plant Physiologist; Water Resources Research Unit, USDA-ARS Conservation and Production Research Laboratory, Bushland, TX
1982-1997	Research Technologist; West Central Research and Extension Center, University of Nebraska, North Platte, NE
1980-1981	Research Assistant, Range Ecology; Dept. of Range Science, Colorado State University, Ft. Collins, CO
1977-1980	Research Technician; West Central Research and Extension Center, University of Nebraska, North Platte, NE

Collaborators and Affiliations

Please refer to the Conflict of Interest list.

Synergistic Activities

Texas A&M Vice Chandellor's Award of Excellence for Research, as member of federal initiative Air Quality team. Served as project's Emissions Objective coordinator. 2009.

Texas Commission on Environmental Quality 2009 Environmental Excellence Finalist, as member of federal initiative Air Quality team. Served as project's Emissions Objective coordinator and principal investigator for ammonia emissions. 2009.

Texas Commission on Environmental Quality 2010 Environmental Excellence Award as member of federal initiative Air Quality team. Served as project's Emissions Objective coordinator and principal investigator for ammonia emissions. 2010.

Federal Laboratory Consortium Mid-Continent Region Notable Technology Transfer Award as member of the Southern Plains Air Quality Team, Sept. 2, 2010, Jackson Hole, WY.

American Society of Agronomy

Soil Science Society of America

Adjunct Professor, Division of Agriculture, West Texas A&M University, Canyon, TX

Publications

Todd, R.W., N.A. Cole, H.M. Waldrip, and R.M. Aiken. 2013. Arrhenius equation for modeling feedyard ammonia emissions using temperature and diet crude protein. J. Environ. Qual. 2013. (accepted for publication).

Parker, D., J. Ham, B. Woodbury, L. Cai, M. Spiehs, M. Rhoades, S. Trabue, K. Casey, R. Todd and A. Cole. 2013. Standardization of flux chamber and wind tunnel flux measurements for quantifying volatile organic compound and ammonia emissions from area sources at animal feeding operations. Atmos. Environ. 66:72-83.

Ro, K.S., M.H. Johnson, K.C. Stone, P.G. Hunt, T. Flesch, R.W. Todd. 2013. Measuring gas emissions from animal waste lagoons with an inverse-dispersion technique. Atmos. Environ. 66:101-106.

Waldrip, H.M., R.W. Todd, and N.A. Cole. 2012. Characterization of ammonium sorption by beef cattle feedyard manure. Trans. ASABE 55(4):1-11.

Casey, K. D., Todd, R.W., Faulkner, W.B., Caramanica, A.P. 2012. Nitrous oxide and methane emissions from beef cattle feedlot surfaces in Texas. ASABE Paper No. 12-1337597, St. Joseph, Mich.: ASABE.

Todd, R.W., N.A. Cole, M.B. Rhoades, D.B. Parker, and K.D. Casey. 2011. Daily, monthly, seasonal and annual ammonia emissions from southern High Plains cattle feedyards. J. Environ. Qual. 40:1-6.

Todd, R.W., N.A. Cole, K.D. Casey, R. Hagevoort, and B.W. Auvermann. 2011. Methane emissions from southern High Plains dairy wastewater lagoons in the summer. Anim. Feed Sci. Technol. 167:575-580.

Hristov, A. N., M. Hanigan, A. Cole, R. Todd, T. A. McAllister, P. M. Ndegwa, A. Rotz. 2011. Ammonia emissions from dairy farms and beef feedlots: A review. Can. J. Anim. Sci. 91:1-35.

Todd, R.W., N.A. Cole, K.D. Casey, R. Hagevoort, and B.W. Auvermann. 2011. Methane and ammonia emissions from New Mexico dairy lagoons. In: Hagevoort, R. (ed.) Proc. Western Dairy Air Quality Symposium, April 20-21, 2011, Sacramento, CA.

Todd, Richard W., N. Andy Cole, and K.D. Casey. 2010. Methane emissions from a southern High Plains dairy wastewater lagoon. In: McGeough, E.J. and S.M. McGinn (Eds.), Proc. 4th International Conference on Greenhouse Gases and Animal Agriculture, Banff, Canada, October 3-8, 2010.

Rhoades, M.B., D.B. Parker, N.A. Cole, R.W. Todd, E.A. Caraway, B.W. Auvermann, D.R. Topliff, and G.L. Schuster. 2010. Continuous ammonia emission measurements from a commercial beef feedyard in Texas. Trans. ASABE 53:1823-1831.

Parker, D.B., E.A. Caraway, M.B. Rhoades, N.A. Cole, R.W. Todd, and K.D. Casey. 2010. Effect of wind tunnel air velocity on VOC flux from standard solutions and CAFO manure/wastewater. Trans. ASABE 53:831-845.

Todd, R.W., N.A. Cole, Casey, K.D., Hagevoort, R., and B.W. Auvermann. 2010. Methane emissions from a New Mexico dairy lagoon system. In: Jordan, E. (ed.) Proc. Air Quality and Manure Management Conf. Sept. 13-15, 2010. Dallas, TX.

Todd, R.W., N.A. Cole, D.B. Parker, M. Rhoades, and K. Casey. 2009. Effect of feeding distiller's grains on dietary crude protein and ammonia emissions from beef cattle feedyards. p. 37-44. In: Jordan, E. (ed.). Proc. Texas animal manure management isssues conference, Sept. 29-30, 2009. Round Rock, Texas.

Cole, N.A., and R.W. Todd. 2009. Nitrogen and phosphorus balance of beef cattle feedyards. p. 17-24. In: Jordan, E. (ed.) Proc. Texas animal manure management isssues conference, Sept. 29-30, 2009. Round Rock, Texas.

Cole, N.A., A.M. Mason, R.W. Todd, M. Rhoades, and D.B. Parker. 2009. Chemical composition of pen surface layers of beef cattle feedayrds. Prof. Anim. Sci. 25:541-552.

Todd, R.W., N.A. Cole, R.N. Clark, T.K. Flesch, L.A. Harper, and B.-H. Baek. 2008. Ammonia emissions from a beef cattle feedyard on the southern High Plains. Atmos. Environ. 42:6797-6805.

Todd, R.W., N.A. Cole, R.N. Clark, Rice, W.C., and W.-X Guo. 2008. Soil nitrogen distribution and deposition on shortgrass prairie adjacent to a beef cattle feedyard. Biol. Fert. Soils 44:1099-1102.

Cole, N.A., and R.W. Todd. 2008. Opportunities to enhance performance and efficiency through nutrient synchrony in concentrate-fed ruminants. J. Anim. Sci. 86:E318-E333.

Cole, N.A., R.W. Todd, B. Auvermann, and D. Parker. 2008. Auditing and assessing air quality in concentrated feeding operations. Prof. Anim. Sci. 24:1-22.

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**** All sections except "Publications" must fit in 2 pages.***

Education and Training (Bachelors through PhD and post-doc information, in chronological order)

Institution	***Major/Area of Study***	***Degree***	***Year***
Berry College, Rome, GA	Animal Science	B.S.	1990
The University of Georgia, Athens, GA	Animal Science	M.S.	1992
The University of Maine, Orono, ME	Ecology and Environmental Science	Ph.D.	2011
Conservation and Production Laboratory, USDA-ARS, Bushland, TX	Research Soil Scientist	Post-doctoral associate	present

Research and Professional Experience (List appointments/positions in reverse-chronological order)

Year – Year	Title, Department, Institution
2011-present	Research Soil Scientist, Conservation and Production Laboratory, USDA-ARS, Bushland, TX
2000-2011	Biological Sciences Technician, New England Plant Soil and Water Laboratory, USDA-ARS, Orono, ME
1998-2000	Senior Research Technologist, Department of Biology, The Pennsylvania State University, University Park, PA
1992-1997	Research Technician II, Department of Poultry Science, The University of Georgia, Athens, GA.
1990-1992	Teaching and Research Assistant, Department of Animal Science, The University of Georgia, Athens, GA

Collaborators and Affiliations
Please refer to the Conflict of Interest list.

Synergistic Activities
Professional Organization Membership

- Soil Science Society of America (SSSA). 2007-present
- American Society of Agronomy (ASA). 2008-present
- Crop Science Society of America (CSSA). 2008-present
- American Chemical Society (ACS) 2012-present
- AGRO, Chemistry for and from Agriculture, Division of ACS 2012-present

Public Service Activities

Editorial board:

- Communications in Soil Science and Plant Analysis 2011-present

Review manuscripts for:

- Communications in Soil Science and Plant Analysis 2011-present
- Agronomy Journal 2011-present
- Biology and Fertility of Soils 2011-present
- Communications in Soil Science and Plant Analysis 2011-present
- Journal of Environmental Quality 2011-present
- Soil Biology and Biochemistry 2011-present
- Soil Science Society of America Journal 2011-present
- Soil Science 2011-present
- Atmospheric Environment 2012-present
- Geoderma 2012-present

Committee Membership:

- Chair-Elect- (ACS449.6) Students of Agronomy, Soils, and Environmental Sciences (SASES) Presentation Contest Committee. ASA-SSSA-CSSA. 2013-2014

- Students of Agronomy, Soils, and Environmental Sciences (SASES) Presentation Contest Committee- **(**ACS449.6). ASA-SSSA-CSSA. 2013-present

Publications

(All publications in refereed journals during the past 4 years, including those in press. Also, non-refereed technical papers with relevance to the project.)

Invited Book Chapters

Waldrip, Heidi M., Veronica Acosta-Martinez, and Zhongqi He (*in process*), Phosphatase activities and phosphorus availability in soils amended with livestock manure. *In* He, Z., and H. Zhang (eds.) Applied Manure and Nutrient Chemistry for Sustainable Agriculture and Environment. Springer Publishing, New York, NY.

Acosta-Martinez, Veronica, **Heidi M. Waldrip**, and Zhongqi He (*in process*), Soil enzyme activities as affected by manure types, rates, and tillage application practices. *In* He, Z., and H. Zhang (eds.) Applied Manure and Nutrient Chemistry for Sustainable Agriculture and Environment. Springer Publishing, New York, NY.

He, Zhongqi, and **Heidi M. Waldrip** (2012), Capillary electrophoresis applications in agricultural and soil chemistry. *In* He, Z. (ed.) Capillary Electrophoresis: Fundamentals, Techniques and Applications. Nova Publishers, Hauppage, NY.

Wang, Yun., Zhongqi He, and **Heidi M. Waldrip** (2012), Capillary Electrophoresis Application in Metal Speciation and Complexation Characterization. *In* He, Z. (ed.) Capillary Electrophoresis: Fundamentals, Techniques and Applications. Nova Publishers, Hauppage, NY.

Refereed Journal Articles

Richard W. Todd, N. Andy Cole, **Heidi M. Waldrip**, and Robert M. Raiken (2013), Arrhenius equation for modeling feedyard ammonia emissions using temperature and diet crude protein. *J. Environ. Qual.* (*in press*)

Heidi M. Waldrip, Richard W. Todd, Changsheng Li, N. Andy Cole, and William Salas (2013), Estimation of ammonia emissions from beef cattle feedyards using the process-based model Manure-DNDC. (*Trans. ASABE, under review*)

Heidi M. Waldrip, Richard W. Todd, and N. Andy Cole (2013), Prediction of nitrogen excretion by beef cattle: A meta-analysis. (*J. Anim. Sci., under review*)

He, Zhongqi, Xiaoyan Cao, Jingdong Mao, Tsutomu Ohno, and **Heidi M. Waldrip** (2013), Analysis of carbon functional groups in mobile humic acid and recalcitrant calcium humate extracted from eight US soils. *Pedosphere (in press*)

Heidi M. Waldrip, Zhongqi He, and Timothy S. Griffin (2012), Effects of organic dairy manure on soil phosphatase activity, available soil phosphorus and growth of sorghum-sudangrass. *Soil Sci.* 177(11):629-637.

Waldrip, Heidi M., Richard W. Todd, and N. Andy Cole (2012), Characterization of ammonium sorption by beef feedyard manure. *Trans. ASABE* 55(4):1609-1619

Waldrip, Heidi M., Zhongqi He, and M. Susan Erich (2011), Effects of poultry manure amendment on phosphorus uptake by ryegrass, soil phosphorus fractions and phosphatase activity. *Biol. Fertil. Soils* 47(4):407-418

Waldrip-Dail, Heidi, Zhongqi He, M. Susan Erich, and C. Wayne Honeycutt (2009), Soil phosphorus dynamics in response to poultry manure amendment. *Soil Sci.* 174(4):195-201

He, Zhongqi., **Heidi W. Dail**, C. Wayne Honeycutt, M. Susan Erich, and Zachary N. Senwo. (2009), Enzymatic quantification of phytate in animal manure. *Commun. Soil Sci. Plant Anal.* 40:566-575