Towards a Verifiable Ammonia Emissions Inventory for Cattle Feedlots in the Great Plains

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Where’s the Beef?

- 9 million head of cattle in beef feedlots across the High Plains
- 85% of U.S. beef feedlot inventory
- Other 15% – IA, CA, AZ, ID, WA

Courtesy of P.I. Coyne
NE Colorado CAFO Map
Reactive Nitrogen Cycling Through the Atmosphere and Ecosystem

Nitrogen Sources

Transport / Transformation

Deposition / Feedback

Roll cursor over source areas to reveal pollutant species and percent of contribution.

lightning

volcanoes and other area sources

fires

industry, power plants

urban and mobile sources

livestock

mobile / urban sources

soil, natural vegetation

oil and gas production

Intro.
Got Beef? Got Ammonia!

- Retention of fed nitrogen in feedlot cattle is typically 13%.
- Most fed nitrogen is excreted in the urine as urea.
- Up to 50% of fed nitrogen can be lost as NH₃.
9 million head x 0.205 kg N excreted /d x 365 days = 673,425 metric tons N/year ≈ 336,712 metric tons NH₃

Could be 10% of total U.S. inventory
Cattle Feedlot NH₃ Reporting Requirements

EPCRA, good faith air emissions estimates on NH₃ and H₂S if over 100 lbs/day

Cattle feedlots over 1000 head must report to state

Must estimate upper and lower limits

Could a manager replace these simplified approaches with results from a site-specific online software tool?
EPA Project Goals

- Measurement and modeling of feedlot NH$_3$ losses to reduce uncertainty in emissions and the inventory.
- Develop tools that will improve the efficiency and accuracy of NH$_3$ reporting by feedlot managers.
- Identify points of intervention in the feedlot system where NH$_3$ emissions might be reduced.
Project Framework

Field Component:
- Long-Term Emissions Measurements and Mass Balance Studies
  Greeley, CO
- Short-Term Emissions Measurements
  Fort Morgan, CO
  Lamar, CO
  Scott City, KS
  Sublette, KS

Modeling:
- Emissions Data From Previous studies in TX
  (Cole, Todd)
- Feedlot Emissions and Transport Modeling
  (Chemical Reactor Analog)
- Emissions Prediction Tool for Feedlot Industry

Emissions Prediction Tool and Inventory:
- Input from Stakeholders
  (Regulators, Cattle Feedlot Industry)
- Required Reporting
- Emissions Database
- Ammonia Inventory By County, State, Region, or U.S.

Emissions Data From Previous studies in TX
(Cole, Todd)

Feedlot Emissions and Transport Modeling
(Chemical Reactor Analog)

Emissions Prediction Tool for Feedlot Industry

Emissions Database

Ammonia Inventory By County, State, Region, or U.S.
Field Component: REA System
New Research: Continuous REA Measurements of NH$_3$ Fluxes

- Picarro 1103
- Ring-down Cavity Analyzer
REA Air Sampling and Analysis System

- Up-Eddy Inlet
- Control Signal
- 3-way Valve
- Filter Holder
- Tower
- Trailer
- Mix Ves.
- MFC
- MFC
- Micro Pump Teflon
- 3-way Valve Teflon
- Picarro NH3
- CO2 Analyzer
- Pump
- Ballast
- Zero Air Generator
Time Constant, Picarro 1103

![Graph showing Time Constant Analysis (1st order)]

- Time (min) on the x-axis.
- Concentration (ppb) on the y-axis.

Graph indicates a decay response with a time constant of approximately 11.63 s, with an R² value of 0.9749.
Next Steps with the REA System

- Optimize REA system design with lab tests and simulations.
- Field deploy and compare fluxes to denuder-based REA
- Begin continuous NH$_3$ emission measurements in March 2011
Modeling the feedlot system as a series of tank reactors

1. Maintains Mass Balance
2. Allows feedback with environment and management
3. Easily adapted for other compounds (GHGs)
Simulated NH₃ Emissions For Northern Colorado Feedlot

Simulated Potential Ammonia Emissions: Greeley, Colorado

- Summer
- Spring
- Fall
- Winter

Date, Fall 2006 to Summer 2007
Potential NH$_3$ Feedlot Emissions

Simulated

Graph showing NH$_3$ flux (g/m$^2$/day) over time from January 2005 to December 2007, with data points for Greeley and Bushland.
Emissions from Intact Soil Cores
Diet Study - Preliminary Results

Reduced N diet: 42% reduction in total pen surface emissions compared to control diet
Next Steps: Modeling

- Lab studies to develop formula for the Henry’s law and equilibrium constants in feedlot manure.
- Test submodels with soil core system
- Compare results to REA flux data from commercial feedlots
BMPs For Ammonia Require an Integrated Approach

Ham, 2008
Methane and Other GHGs