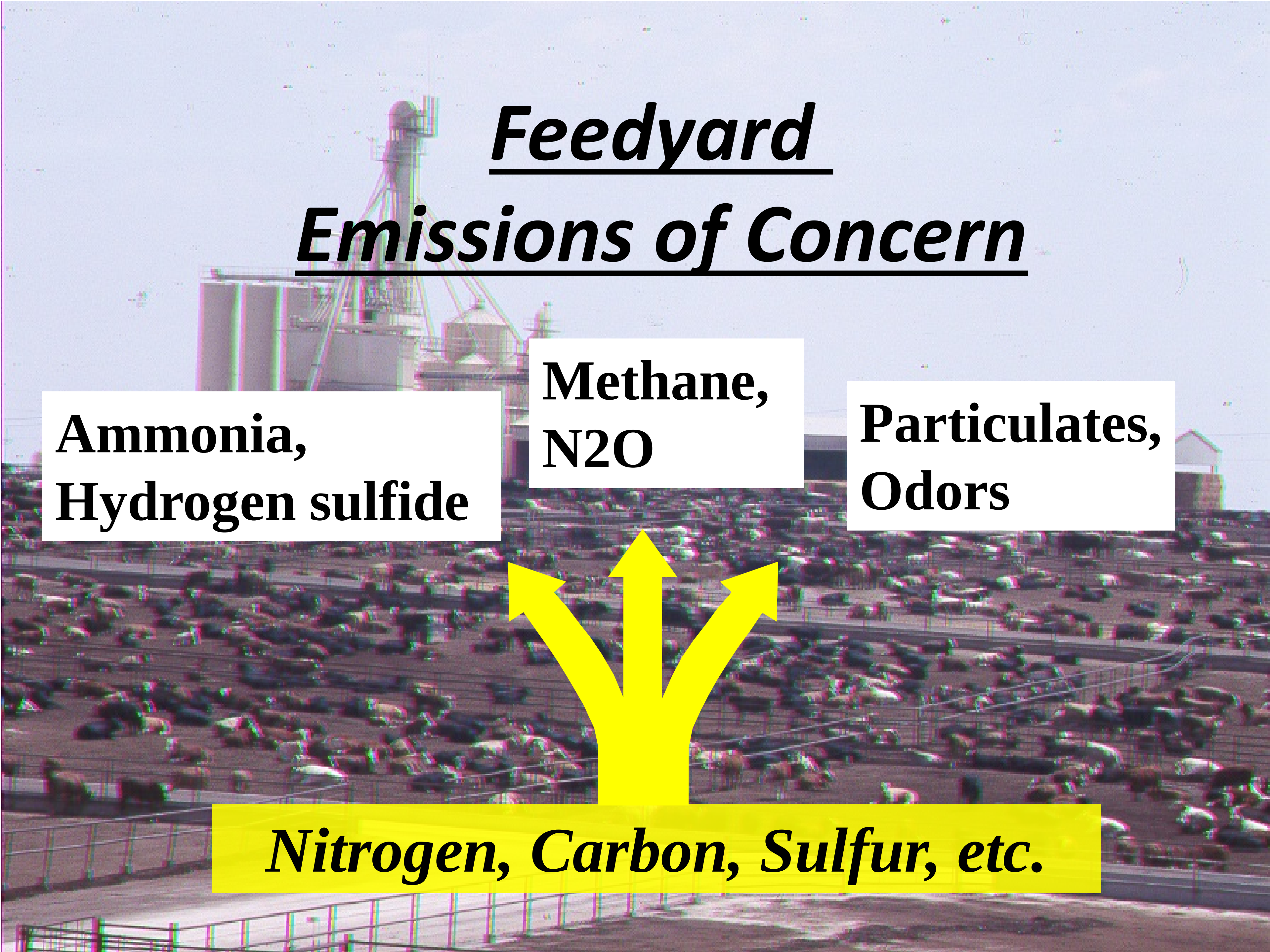
Feed Management for Beef Feedlots to Reduce Air Emissions

N. Andy Cole, R. W. Todd, H. Waldrip, and K. Hales; USDA-ARS-CPRL, Bushland, Texas

Overview

- ***Background***
- Review of feedlot nutrition
- Greenhouse gases
- Ammonia
- Odors / volatile organic compounds (VOC)
- Dust / PM
- Progress made
- Closing thoughts

Feedyard Emissions of Concern



Effects of AFO Emissions

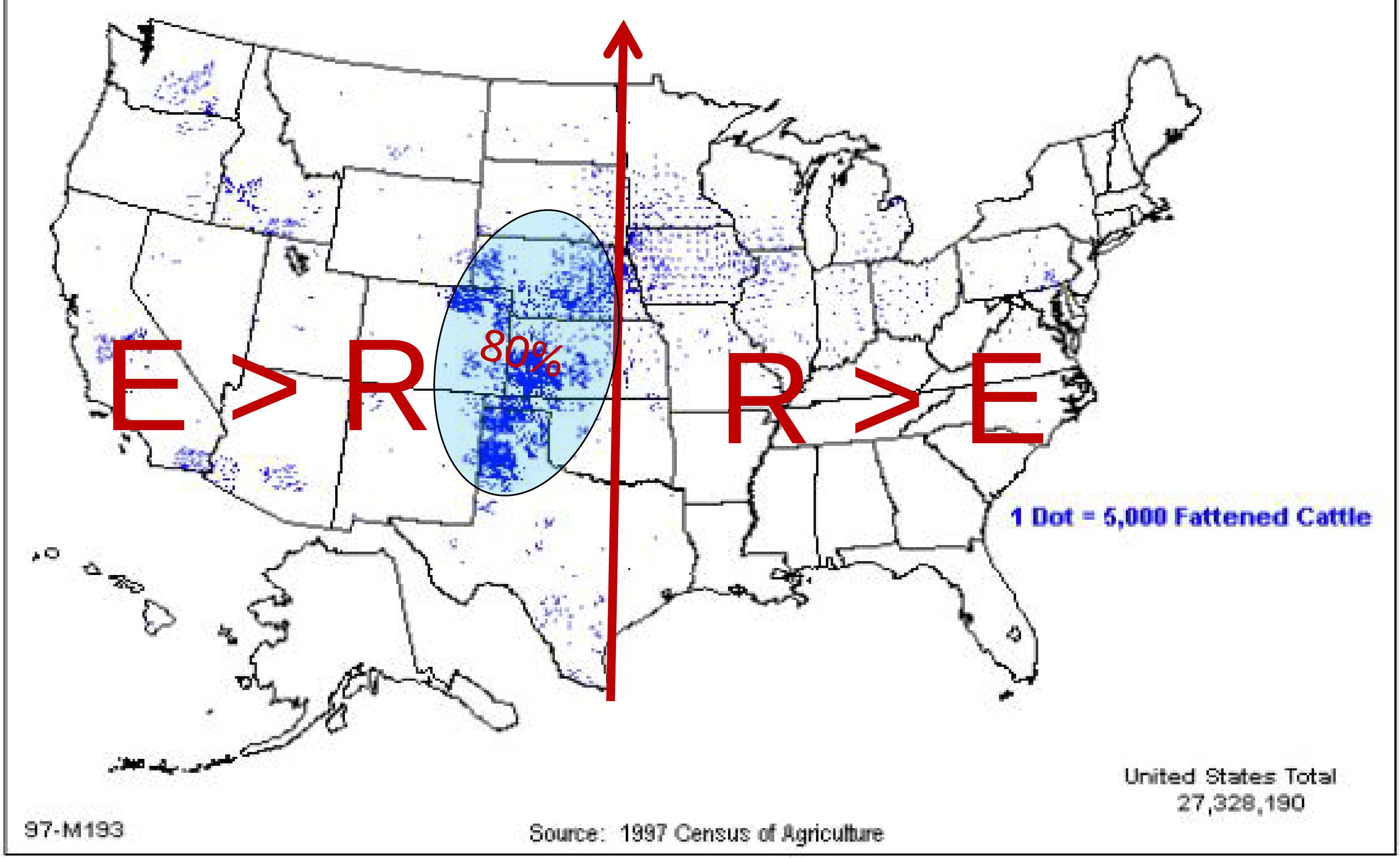
- Global Climate Change (GHG)
- Atmospheric deposition (NH_3)
- PM2.5 formation (NH_3 + people)
- Regional Haze (NH_3 + people)
- Fertilizer N loss (NH_3)
- Quality of life (dust, odors)
  - Health
  - Nuisance

Feedyard Emission Sources

Background

- In North America
  - Most finished cattle spend 100 to 180 days in a feedlot/feedyard (20-25 million head)
    - In weights 500 to 800 lb
    - Out weights 1200 to 1400 lb
  - Diets consist of high-grain and/or high-byproduct
  - Cattle feeding today is inexorably linked to the grain ethanol and corn by-products (starch, oil, sweetener) industries

Average Annual Rainfall vs. Evaporation



Northern vs. Southern Plains Feedlots

- Terrain: rolling vs. flat; Creeks & streams
  - Feedlot size: Northern < Southern
- Diets
  - North – feed more byproducts & Dry rolled corn
  - South – Steam flaked corn
- Manure / head: North > South
- Land for manure application
  - North – some feedlot owned land
  - South – contract with local farmers

Overview

- Background
- **Feedlot Nutrition Overview**
- *Greenhouse gases*
- Ammonia
- Odors / volatile organic compounds (VOC)
- Dust / PM
- Progress made
- Closing thoughts

Feed Proteins

- Crude Protein
  - Nitrogen x 6.25
  - Rumen degradable protein (RDP / DIP)
    - Utilized by microbes in rumen to ferment CHO, reproduce, produce cell protein, etc.
  - Rumen undegradable protein (RUP / UIP)
    - Bypass / Escape protein

RDP of Feeds (% of CP)

- Urea – 100%
- Alfalfa – 77%
- Soybean meal – 65%
- Cottonseed meal – 55%
- Corn – 50%
- Distiller's grains – 30%
- Feather meal – 30%

Cattle Have 2 Protein Requirements

- Rumen degradable protein (RDP)
  - For microbes to grow (i.e. make microbial protein)
  - Microbial Crude Protein (MCP) = 80% protein
- Metabolizable Protein
  - For the animal
  - Sum of RUP & MCP absorbed from intestine
  - About 80% of RUP and 64% of MCP

Microbial Protein Synthesis

- MCP synthesis
  - Energy and pH dependent
  - RDP requirement varies with energy source (DRC vs. SFC, etc.)
- Balance of RDP & potential “MP” in feeds is not the same as the animals requirements
- Sometimes have to “overfeed” RUP to meet RDP requirement

Distiller's Grains

Per bushel of grain:

- 1/3 ethanol,
  - 1/3 CO_2,
  - 1/3 DGS
- High in N, P, S, fat, and fiber
- Fed wet or dry

Typical Diets Fed in Feedyards, %

Ingredient	"Hi grain"	Hi by-products
Corn (DR, HM or SF)	75	48
Hay or silage	7	7
Wet distiller's grains	0	20
Wet corn gluten feed	0	20
Fat	3	0
Molasses, etc.	5	0
Protein supplement	5	0
Vitamin & minerals	5	5

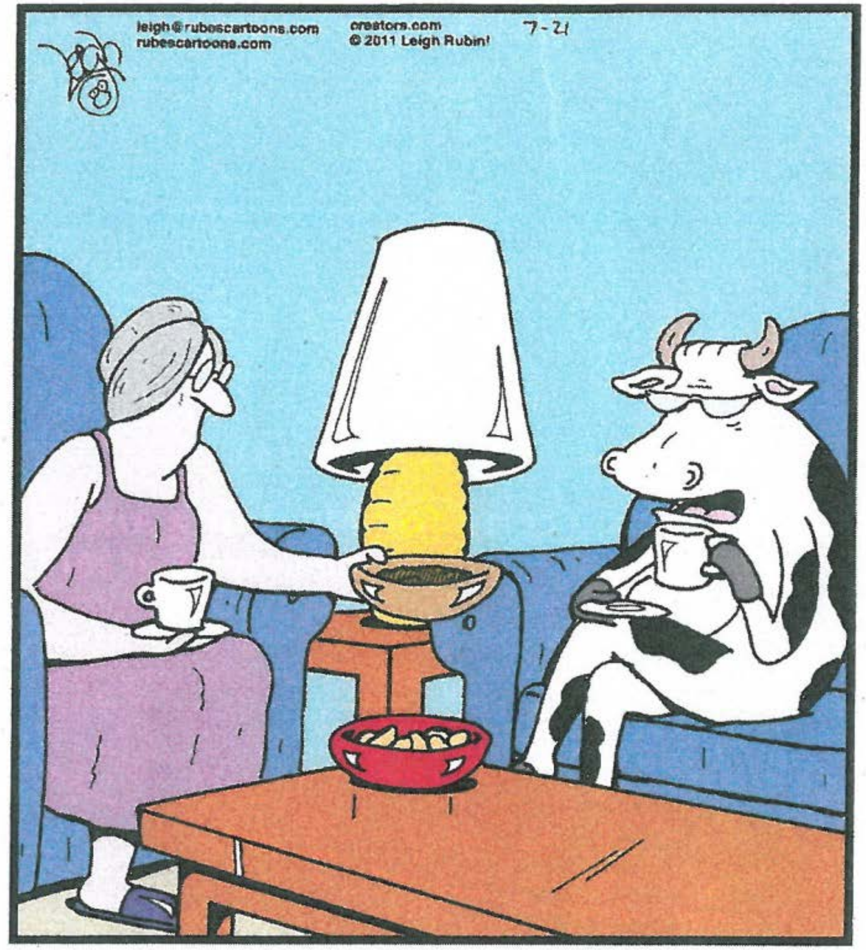
Most include ionophore and an Implant program

Overview

- Background
- ***Greenhouse gases***
- Ammonia
- Odors / volatile organic compounds (VOC)
- Dust / PM
- Progress made
- Closing thoughts

The Carbon Footprint of Cattle Production

RUBES® By Leigh Rubin



"No more bean dip for me, dear. I'm trying to reduce my carbon footprint."

Beef Cattle GHG Emissions

- Enteric & metabolic emissions - CH_4 & CO_2
  - Enteric CH_4 – primary cattle GHG
    - Natural in all ruminants
  - Metabolic CO_2 = crop uptake
- Manure emissions
  - CH_4 – varies with conditions, but minor in feedlots
    - Can be significant from lagoons
  - N_2O – Major manure GHG in feedlots (CO_2e = 310X)
- Others / Indirect
  - Feed production, Fossil fuel use, manufacturing

C-Footprint of Beef Cattle Industry

Some “Common” Results (5 studies)

- 6 to 19 Kg CO_2e / kg slaughter weight
- Cow-Calf Operation – 64 to 82%
- Feedyard phase – 12 to 16%
- Enteric CH_4 - 55 to 63%
- Manure N_2O -18 to 23%
- Secondary emissions - 14 to 24%
- Grass-finished > Grain-finished (0-30%)

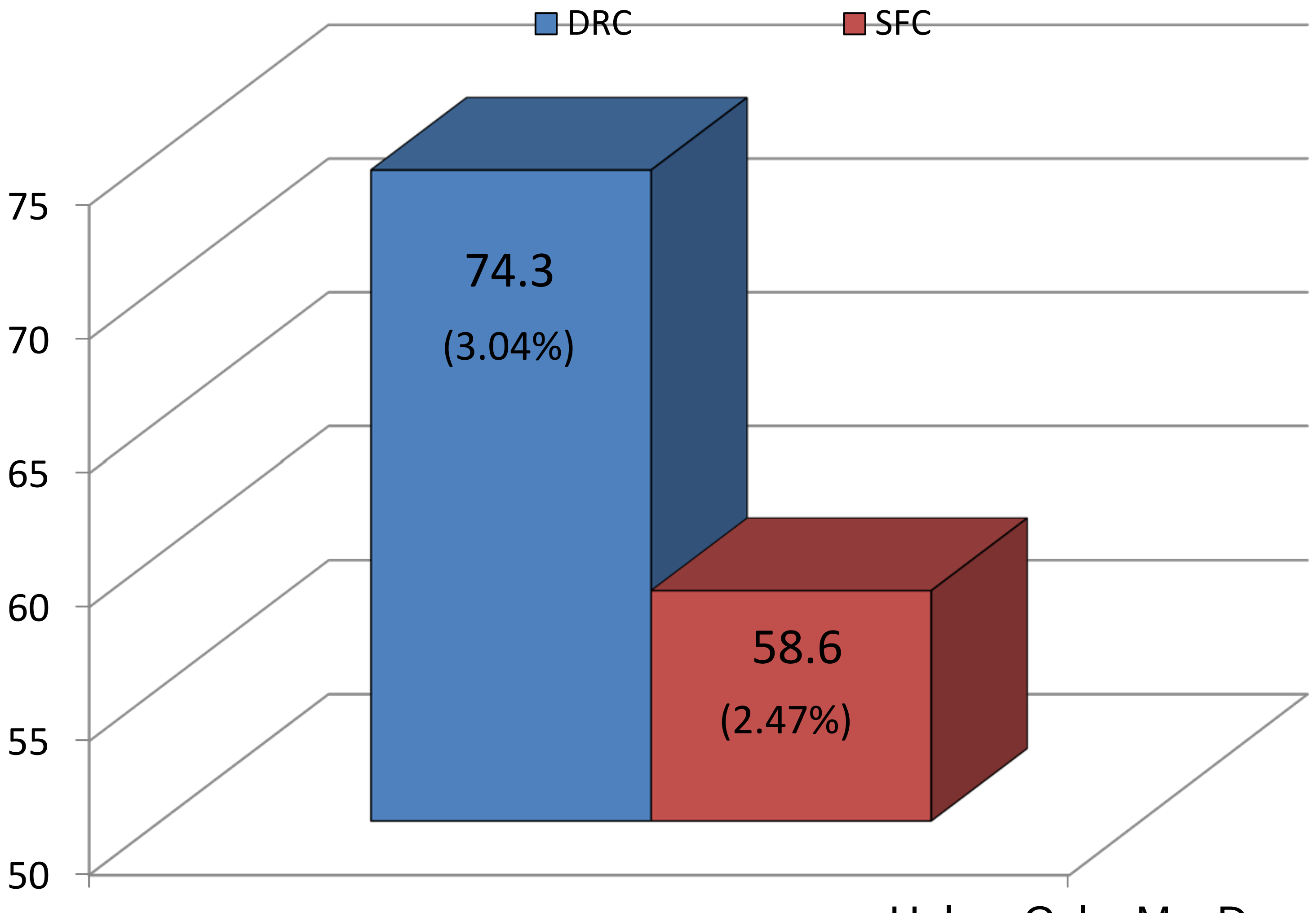
Factors Affecting Enteric CH_4

- Starch (grain) content & fermentability
  - Increased starch decreases CH_4 (as % of GEI)
- Roughage content & quality
  - Increased roughage increases CH_4
- Fat / Lipids
  - Increased fat decreases CH_4 (to about 8% fat)
- Ionophore (monensin)

Factors Affecting Manure GHG

- Manure CH_4
  - Carbohydrate excreted
    - Form, fermentability
  - Weather / Pen surface conditions
- Manure N_2O
  - N excretion
  - Weather / Pen surface conditions
    - Aerobic & anaerobic

Enteric Methane, L/day (% of GE)



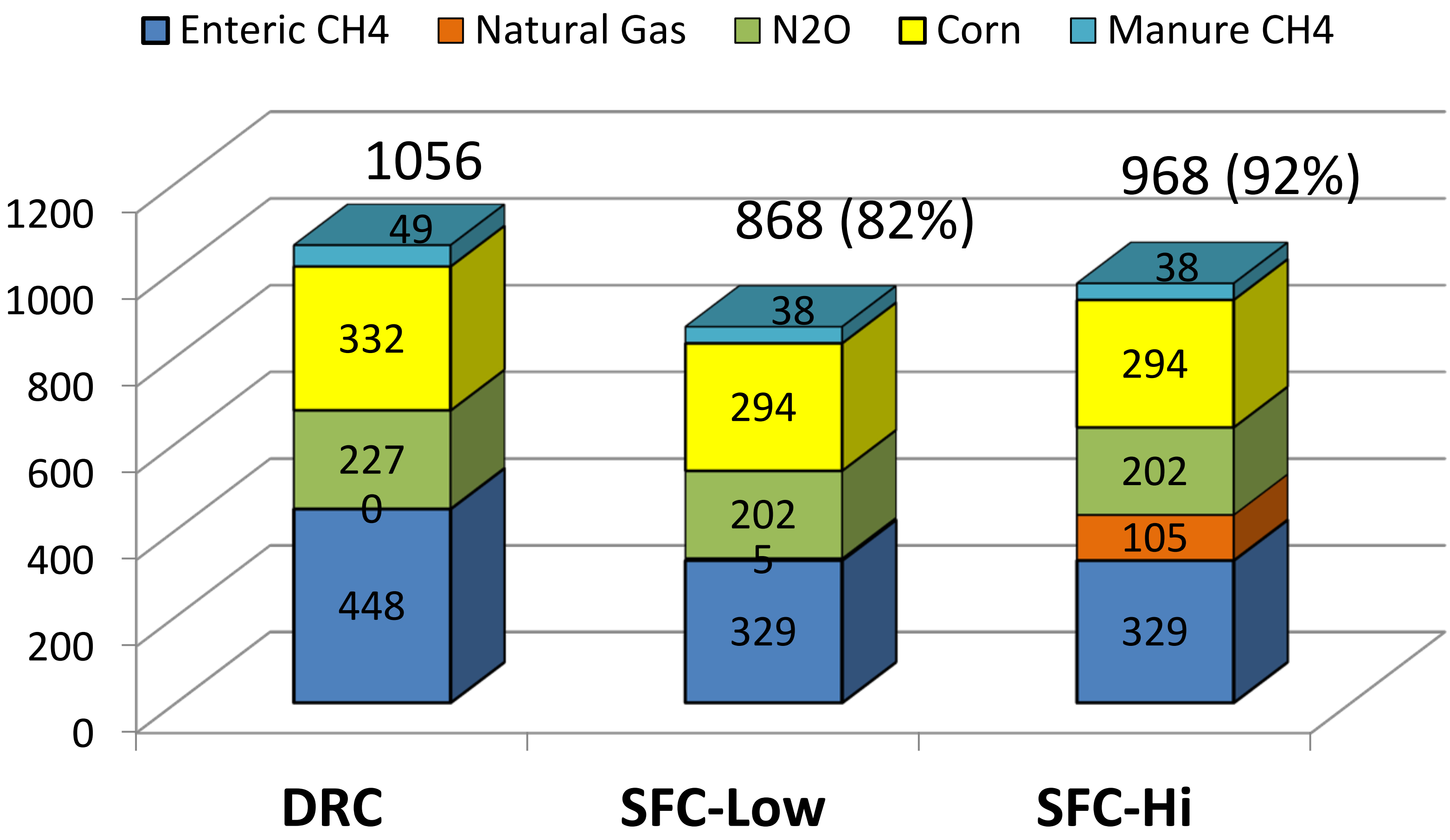
Hales, Cole, MacDonald, 2012

Grain Processing and C-Footprint

- Steam flaking vs. dry rolling corn
  - Uses additional fossil fuel (12.8 m^3 / t corn DM)
  - Decreases DM and grain intake (10-15%)
  - Increases gain:feed (10-15%)
  - Decreases enteric CH_4 (20-25%)
  - Increases digestibility of OM & starch (5-25%)
    - Decreases manure solids (35-50%)
    - Decreases starch (VS) in manure (20-80%)

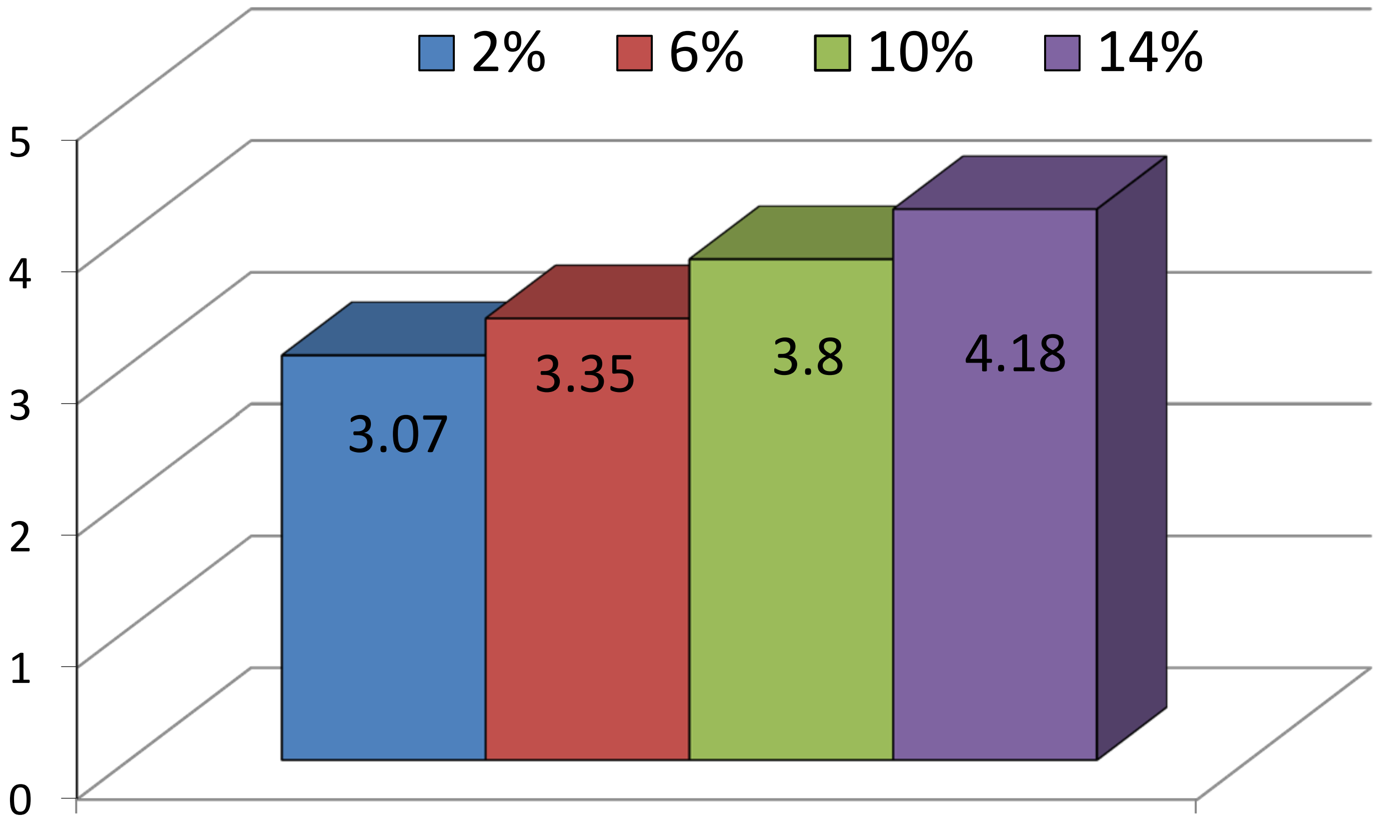
Steam Flaking & Carbon Footprint

Kg CO2e / 150 Days on Feed



Diet Roughage % & Enteric CH_4

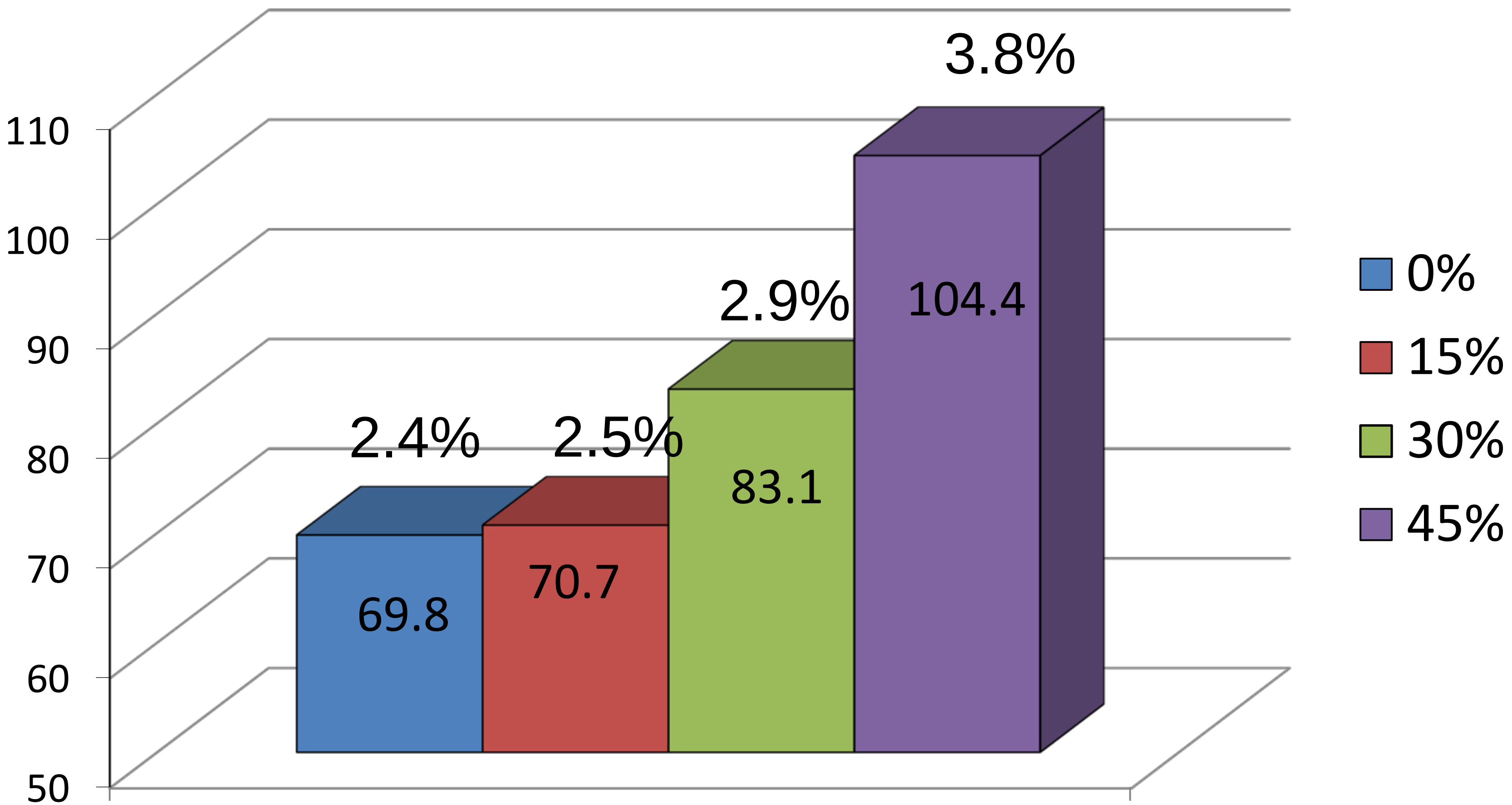
% of GEI



Hales, et al, 2014

WDGS % & Enteric CH4

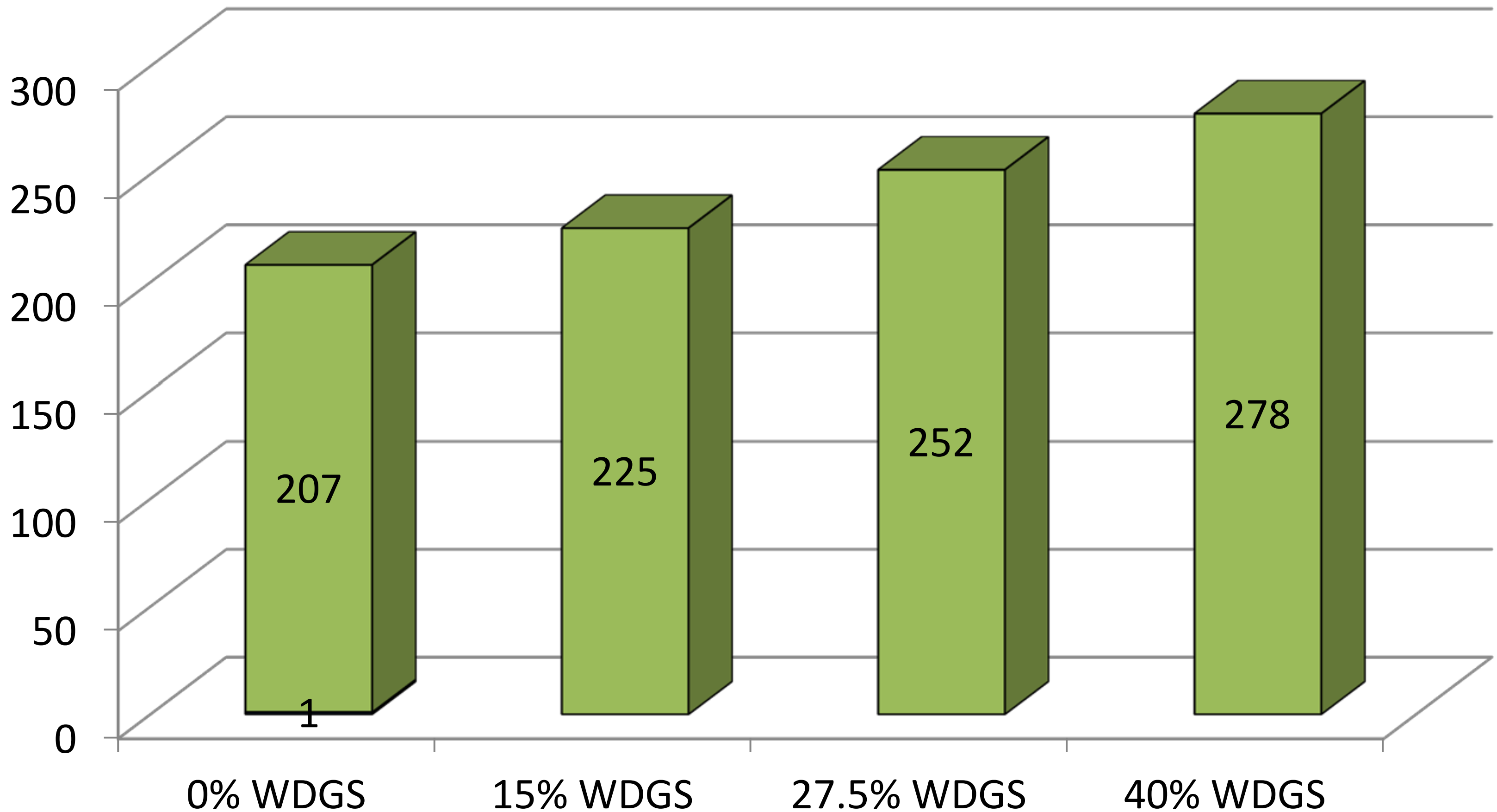
L/day (% of GEI)



Hales, Cole, MacDonald, 2012

WDGS and Manure N2O Emissions

Kg CO2e / head (167 DOF)



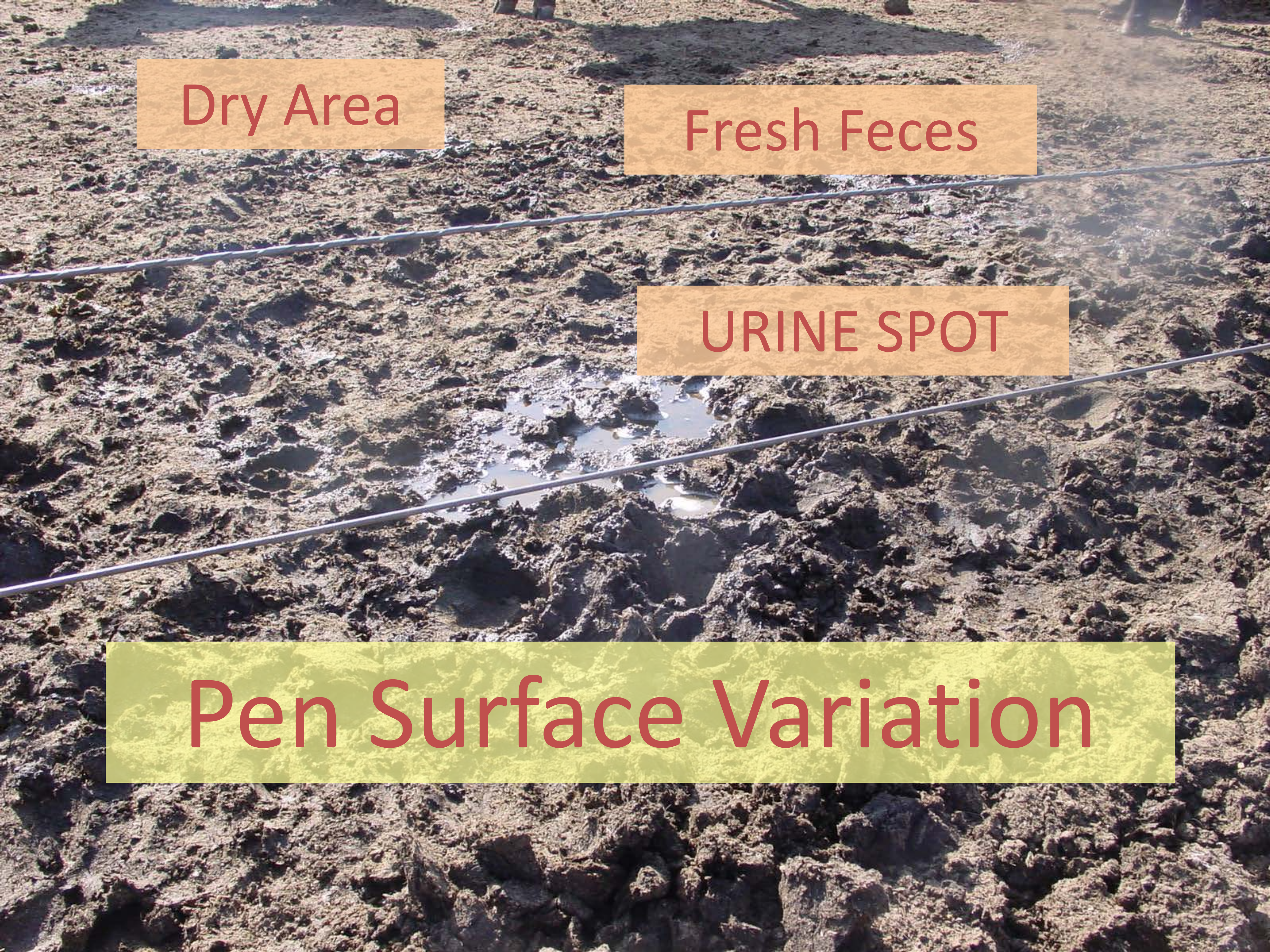
Corrigan et al., 2009; Luebbe et al., 2012; Buttrey et al., 2013; Hales et al 2012, 2013

Effects of Distillers Grains on the C-Footprint of Cattle Feeding

- Effects are dependent upon
  - Concentration of DGS in diet
    - Increases with increased WDGS
  - Grain processing method
    - Effect less in DRC than SFC
  - Dietary fat supplementation
  - Roughage source (i.e. protein)
  - C-footprint of DGS (= 0, 33, 67, 100% corn??)

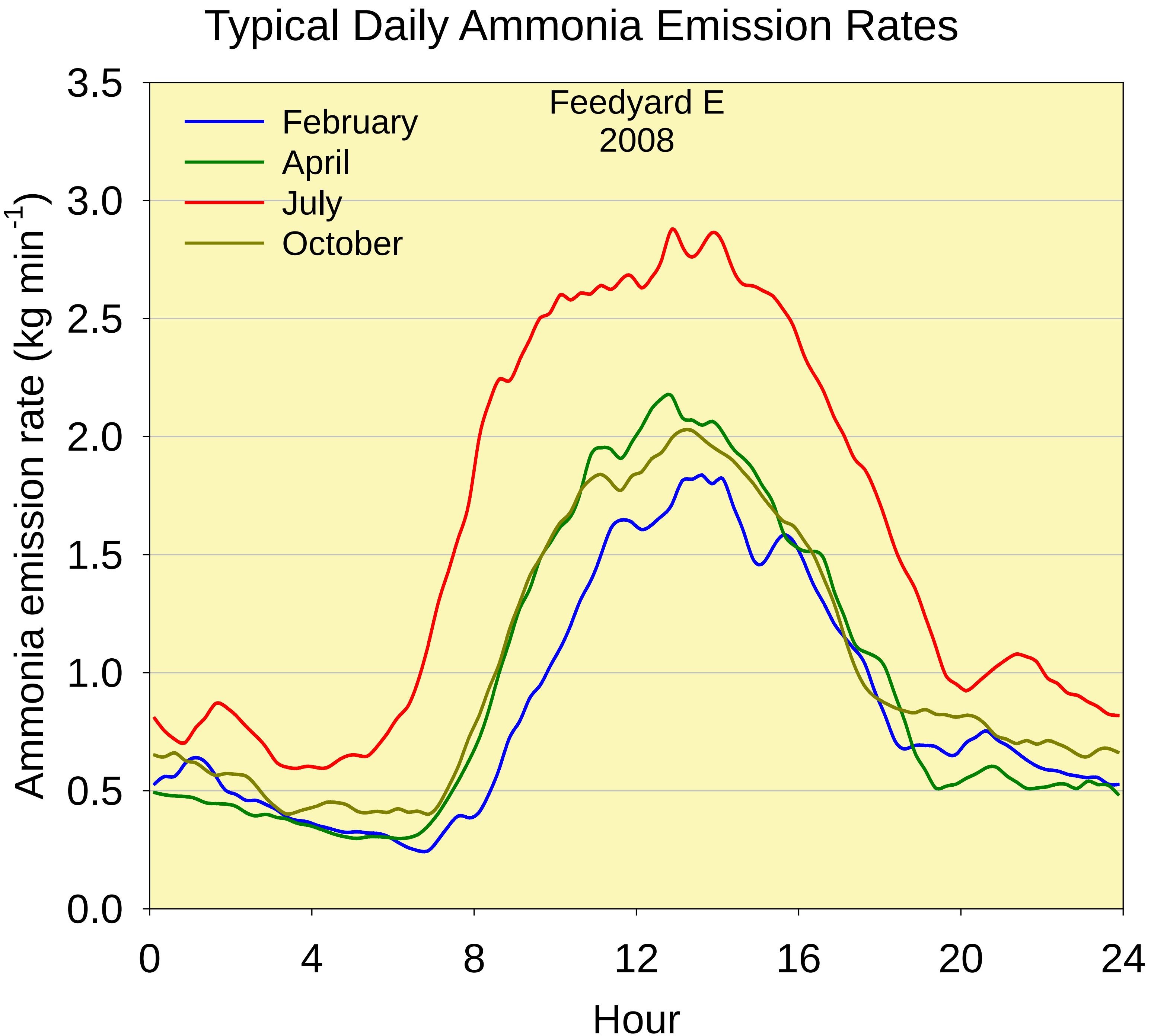
Overview

- Background
- Greenhouse Gases
- ***Ammonia***
- Odors / volatile organic compounds (VOC)
- Dust / PM
- Progress made
- Closing thoughts


Dry Area
Fresh Feces
URINE SPOT
Pen Surface Variation

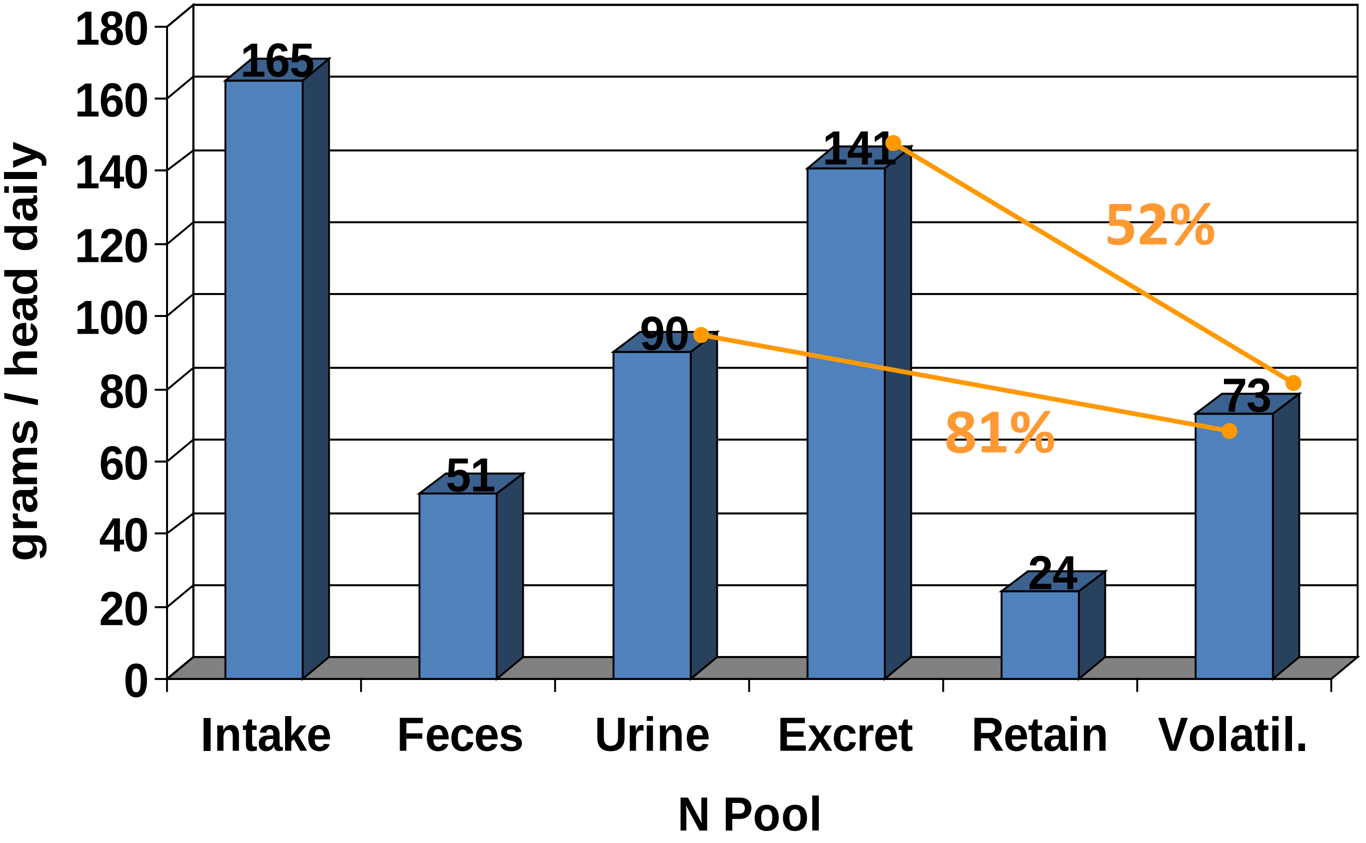
NH3 Loss from Urinary Urea

$$\underset{\text{Urea}}{H_2N-\overset{\displaystyle O}{\overset{|}{C}}-NH_2} \xrightarrow[\text{Urease}]{H_2O} 2\,NH_3 + CO_2$$

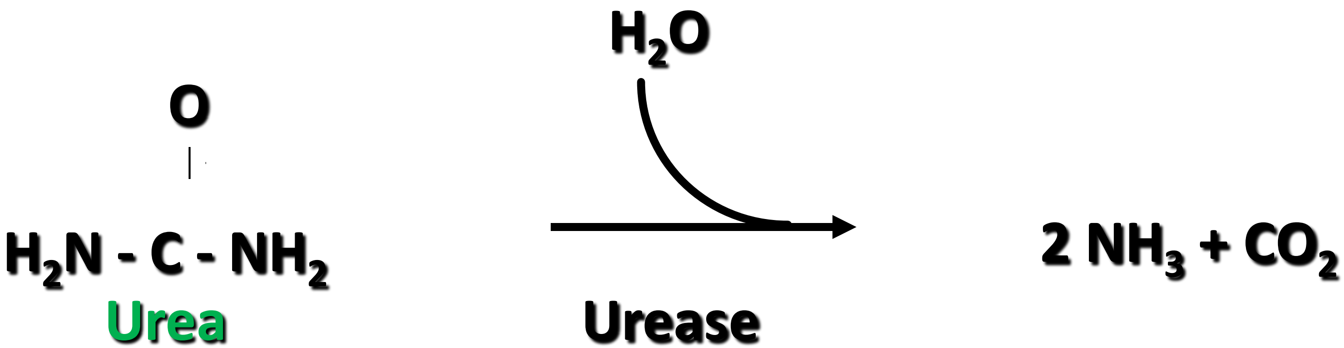


Typical Daily Ammonia Emission Rates
Feedyard E
2008
February
April
July
October
Ammonia emission rate (kg min-1)
Hour
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
0
4
8
12
16
20
24

Average Nitrogen Balance (g/hd/d)



Potential Methods to Decrease NH3 Loss

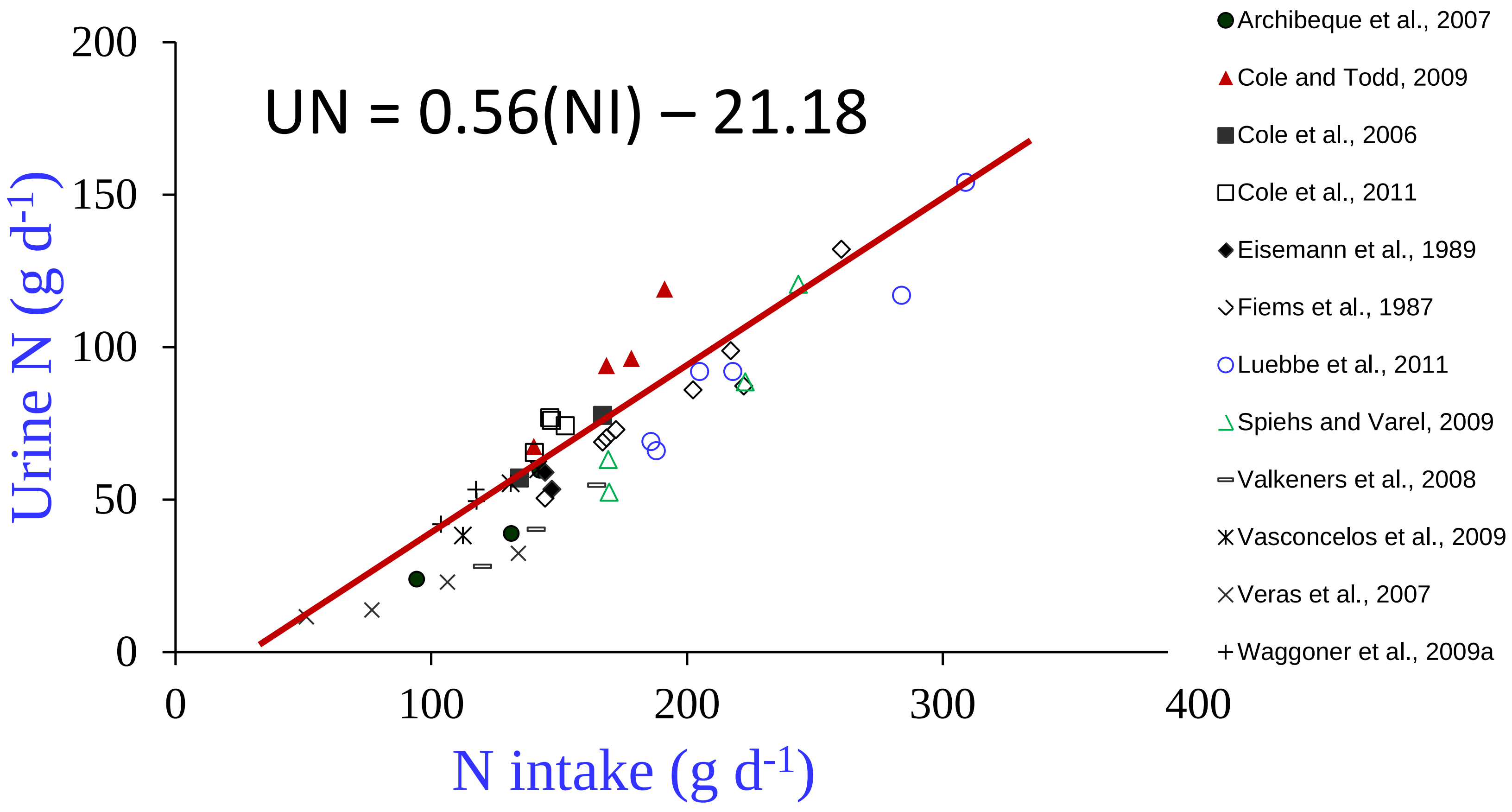


Decrease excretion

Inhibit hydrolysis

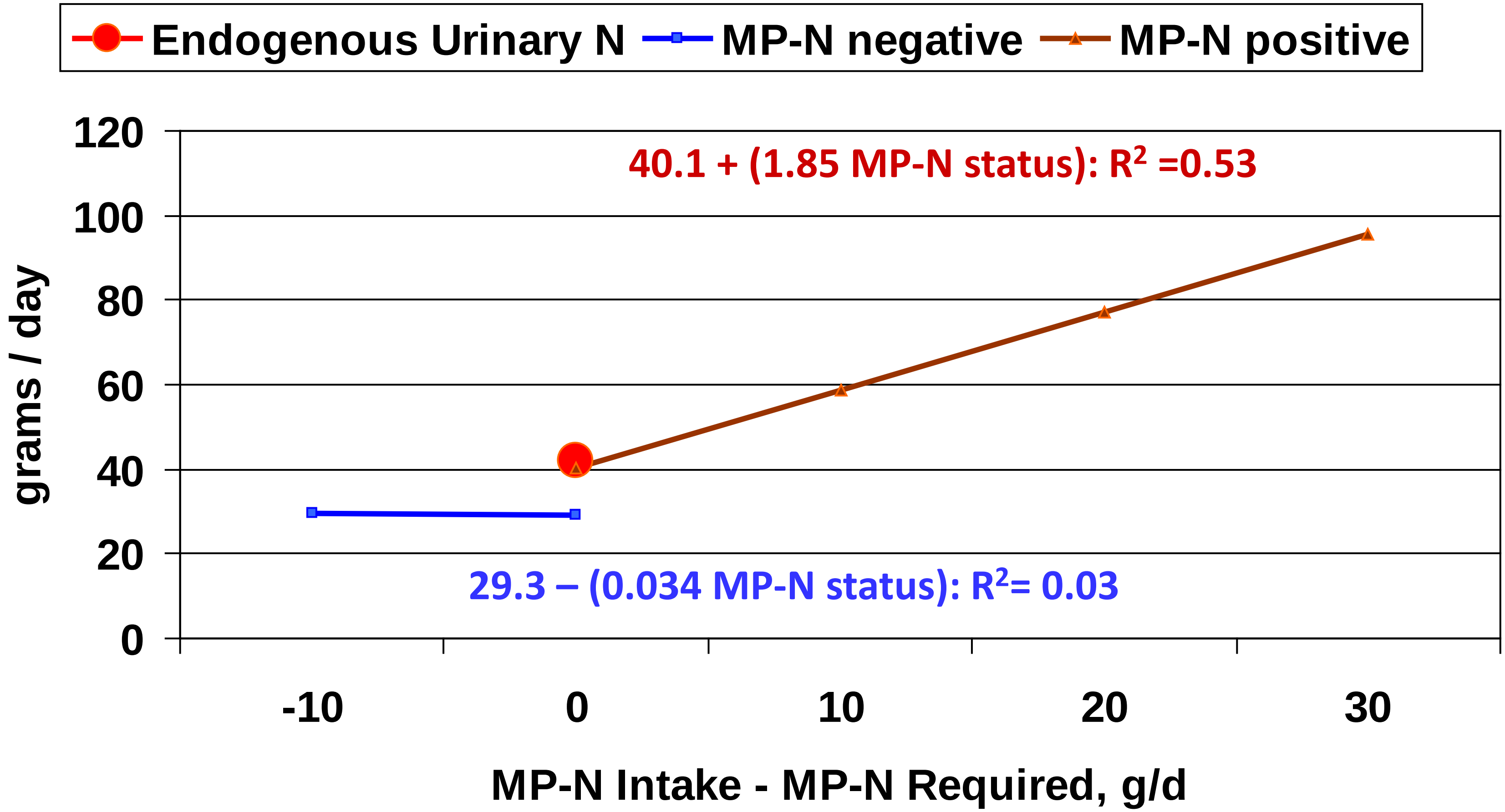
Bind or convert to NH_4^+

N Intake and Urine N



MP-N Status & N Volatilized

(g / head daily)



Cole & Todd, 2009

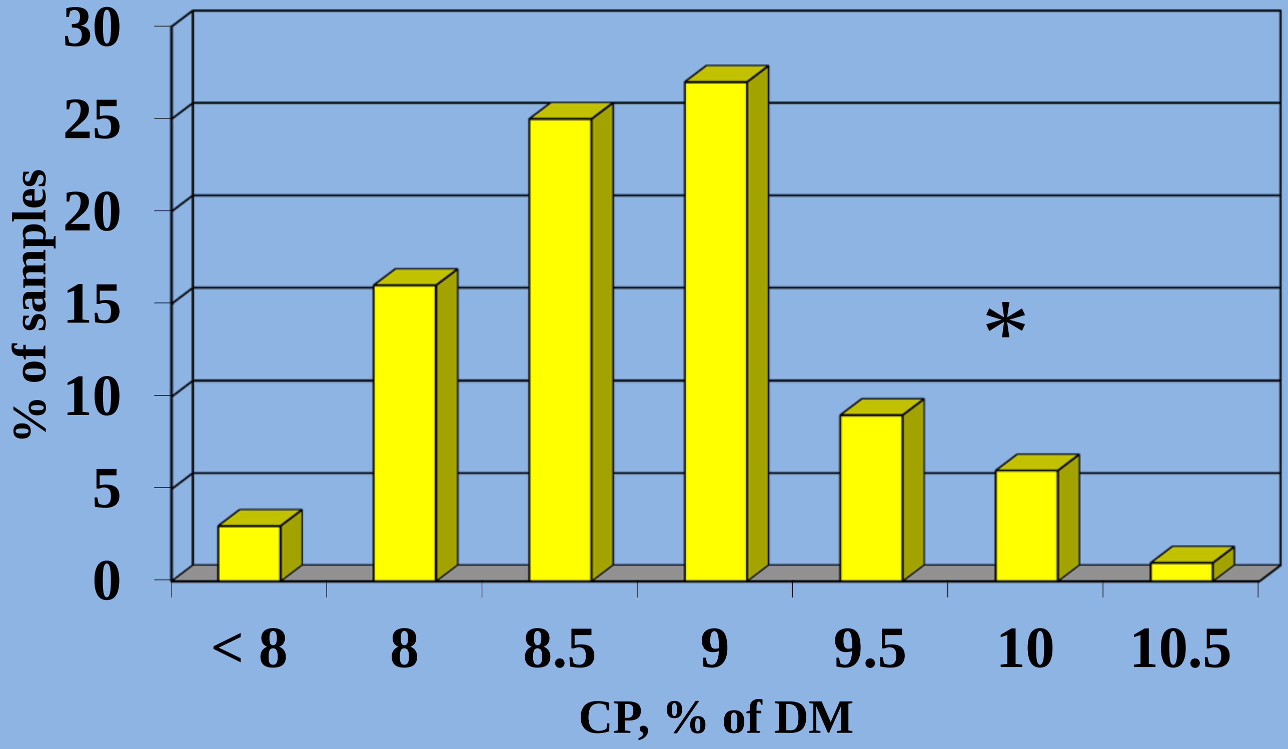
Temp, Diet CP & NH3

Equation : Ln NH3 (g/hd/day)	r2
Ln NH3 = 14.40 – 2809 (1/T, K)	0.84**
Ln NH3 = 8.82 -1629 (1/T) + 0.108 (%CP)	0.80**

Todd et al., 2013 JEQ 42:666

Optimizing Nitrogen Inputs to Finishing Beef Cattle: Easier Said – Than Done

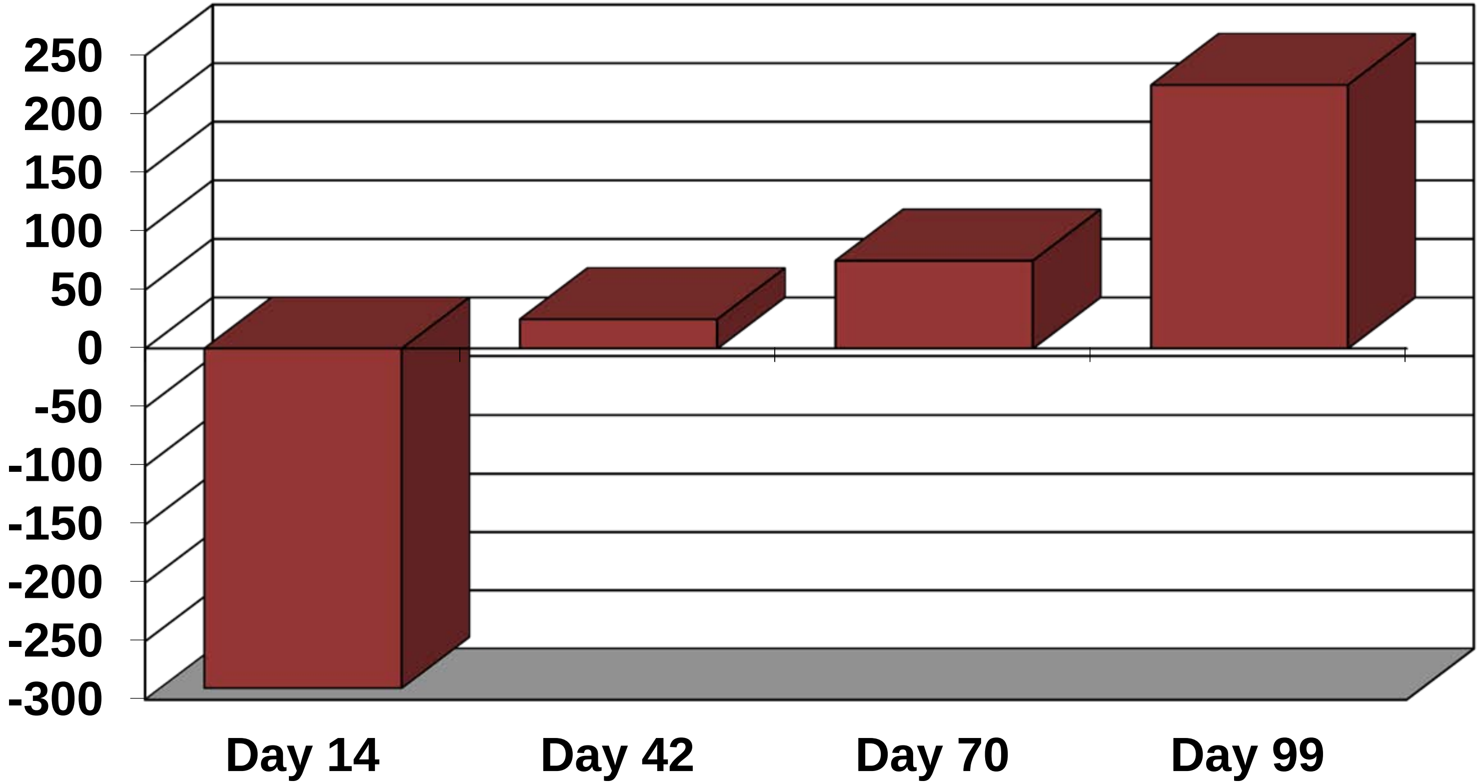
Variation in CP % of Corn



Variation in Cattle

CP Deficiency or Excess During Feeding

g/head daily

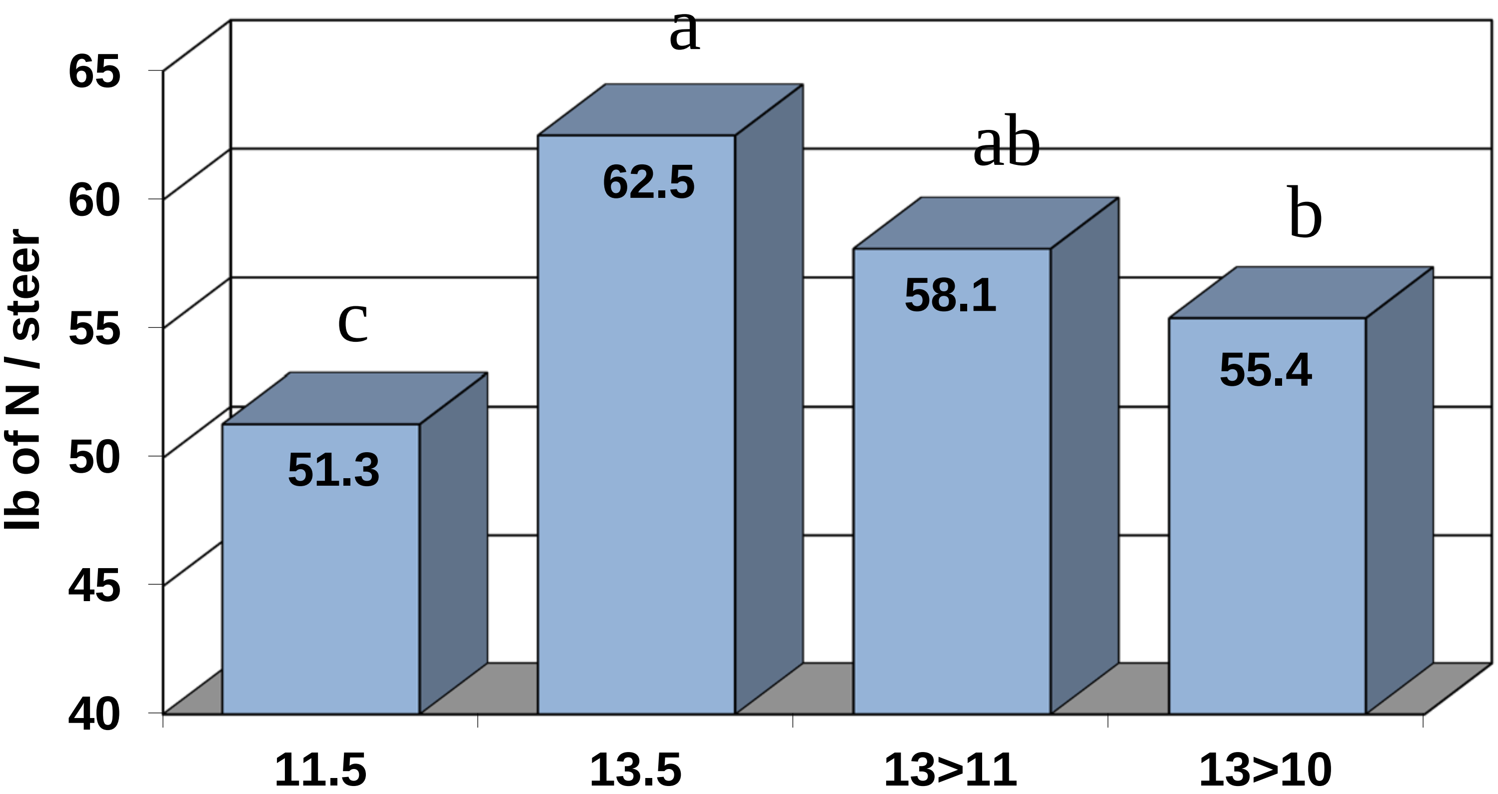


Phase Feeding

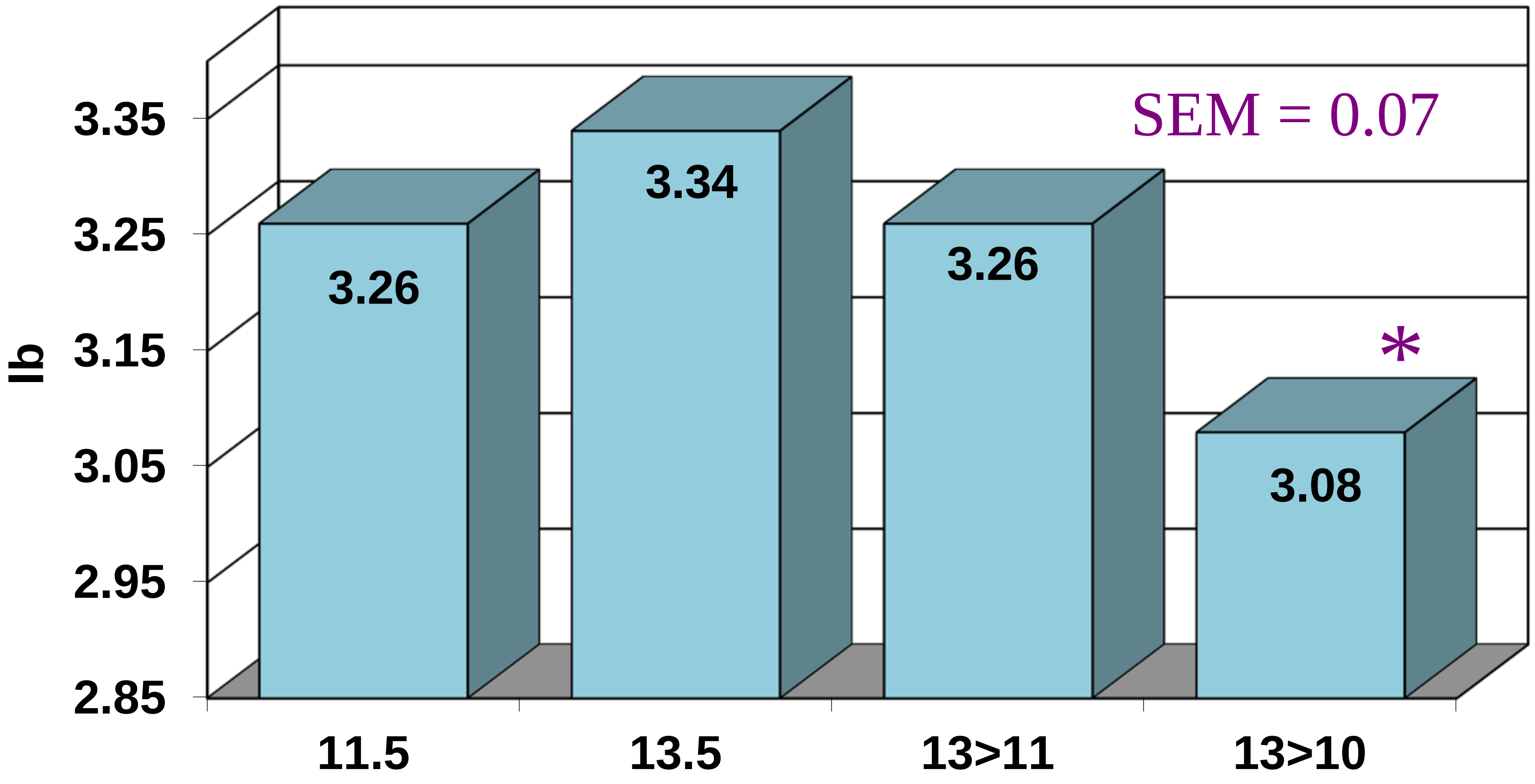
Adjusting dietary nutrient concentrations to meet animal requirements and decrease nutrient losses

Estimated N Volatilization Losses

lb per steer (180 DOF)



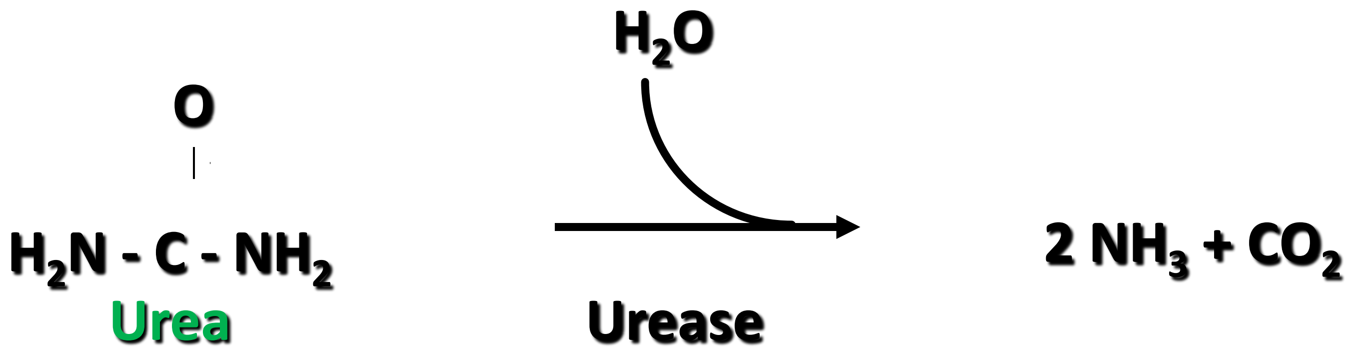
ADG – 167 Day Overall (lb)



Summary – Phase Feeding

- The most opportune time to decrease "safety margins" in rations may be near the end of the feeding period
- Effects on animal health (acidosis, etc.) need to be determined
- Phase feeding may work best with "lower acid load" diets (i.e. DRC vs. SFC).
- Feedmill & feed truck logistics complicate use
- Use of beta-agonists last 20-40 days??

Decreasing NH3 Losses:
Pen Surface Amendments

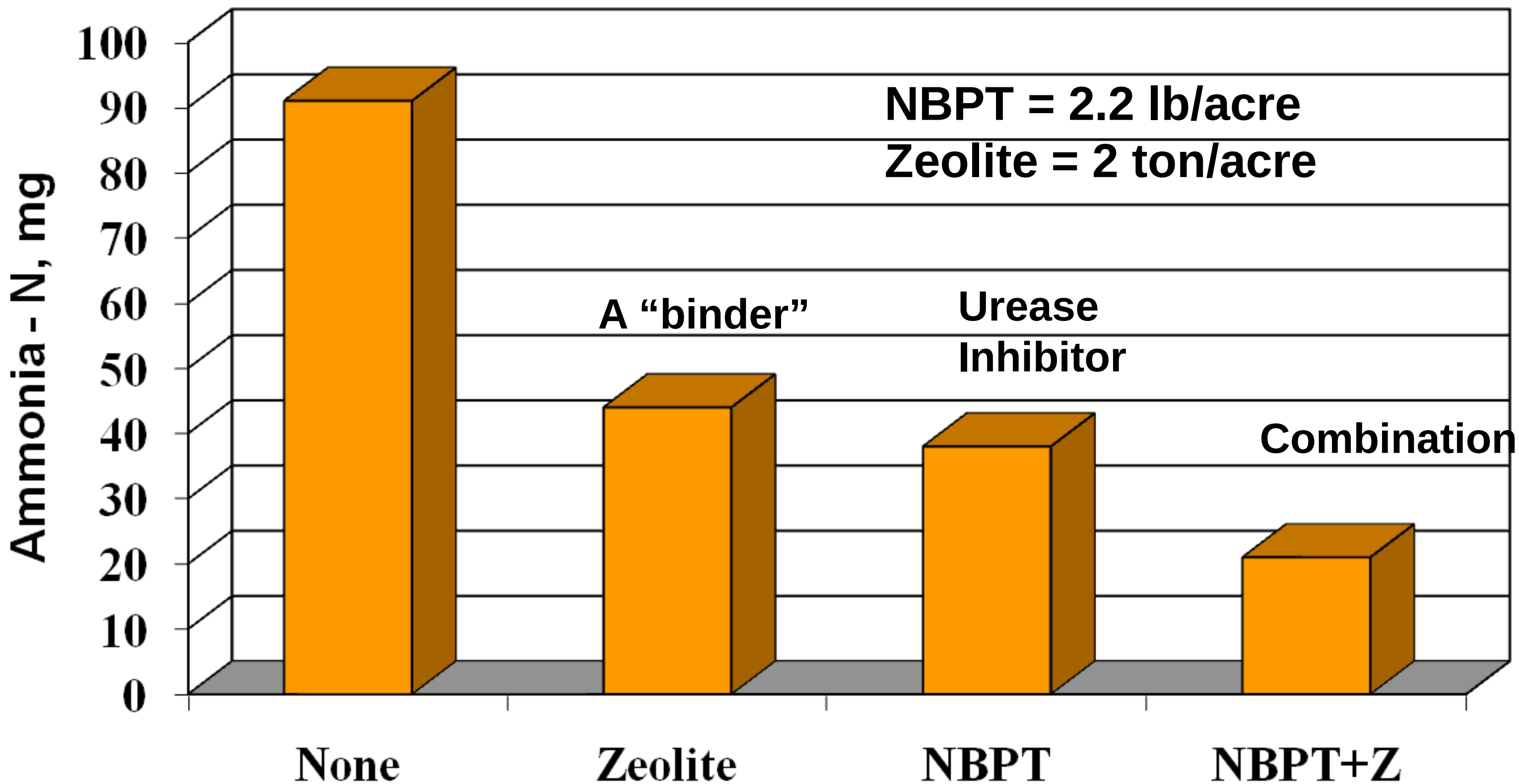


Decrease excretion

Inhibit hydrolysis

Bind or convert to NH_4^+

Surface Amendments & Lab Scale
In Vitro Ammonia Losses



Cole et al., 2008

NBPT = N-(n-butyl) thiophosphoric triamide

Overview

- Background
- Greenhouse Gases
- Ammonia
- ***Odors / volatile organic compounds (VOC)***
- Dust / PM
- Progress made
- Closing thoughts

Odors / VOC

- The problem with odor
  - Odor strength (Odor units / detection threshold)
  - Frequency of occurrence
  - Duration of occurrence
  - Offensiveness – hedonic tone
- Methods to measure
  - Human Nose – Scentometers / Olfactometry, etc.
  - GC-MS

Methods to Decrease Feedlot Odors?

- Decrease starch excretion
  - Grain processing
- Decrease sulfur intake / excretion
- Improve pen drainage
  - Decrease low spots
  - Keep pens dry
- Manage settling basins / retention ponds

Overview

- Background
- Greenhouse Gases
- Ammonia
- Odors / volatile organic compounds (VOC)
- ***Dust / PM***
- Progress made
- Closing thoughts

Particulate Matter

Feedyard PM

- Feedyard dust
  - is a nuisance
  - is mostly organic (manure, dander)
  - is mostly larger particles > PM10
- Concentrations generally greatest at dusk
  - Animal activity
  - Stable atmospheric conditions

Possible Methods to Decrease Dust?

- Feeding supplemental fat
  - Fat in manure may bind particles
- Highly processed grains
  - Less manure
- Higher concentrate diets
  - Less manure
- Pen surface moisture > 20%

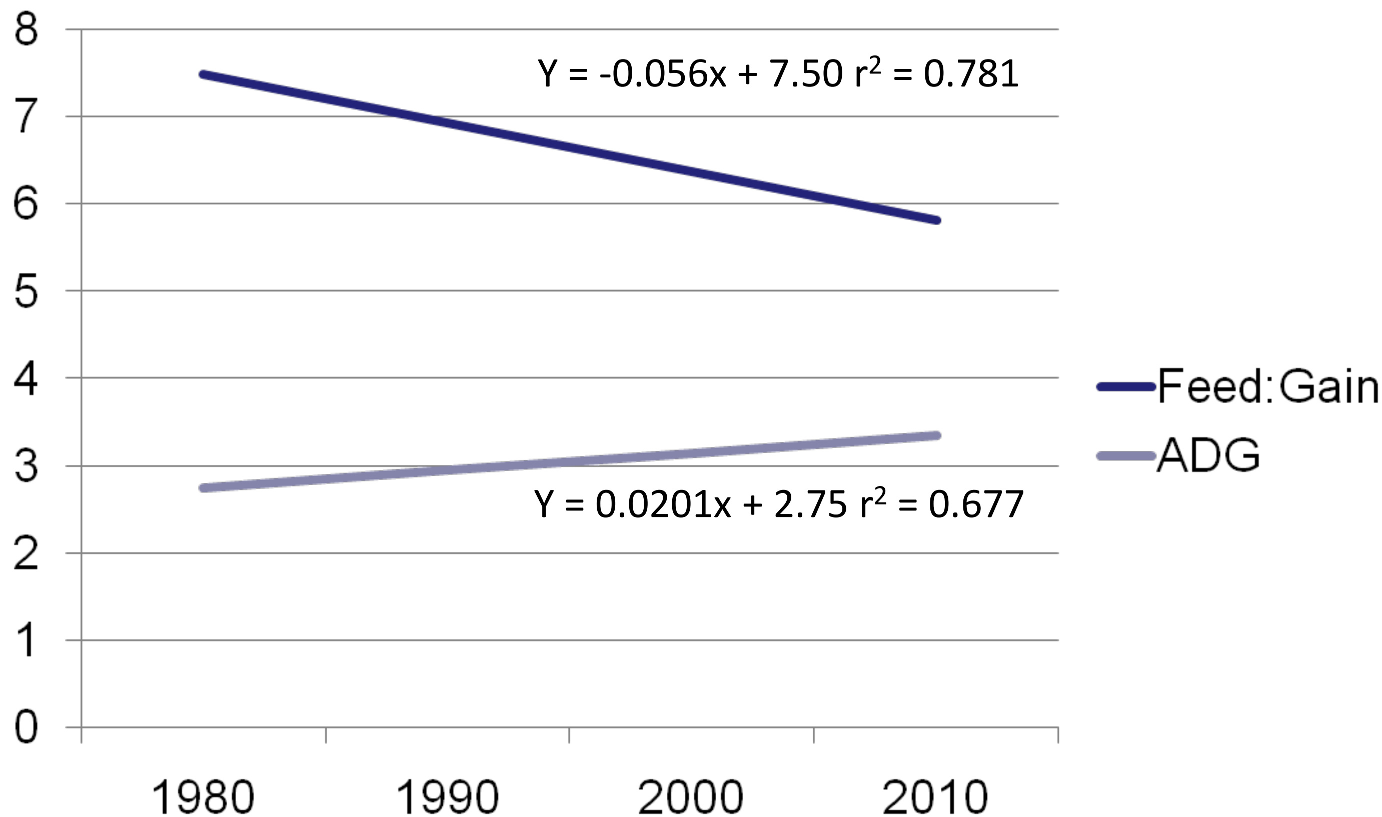
Overview

- Background
- Greenhouse Gases
- Ammonia
- Odors / volatile organic compounds (VOC)
- Dust / PM
- ***Progress made***
- Closing thoughts

Technologies Developed & Improved Over Past 30+ Years

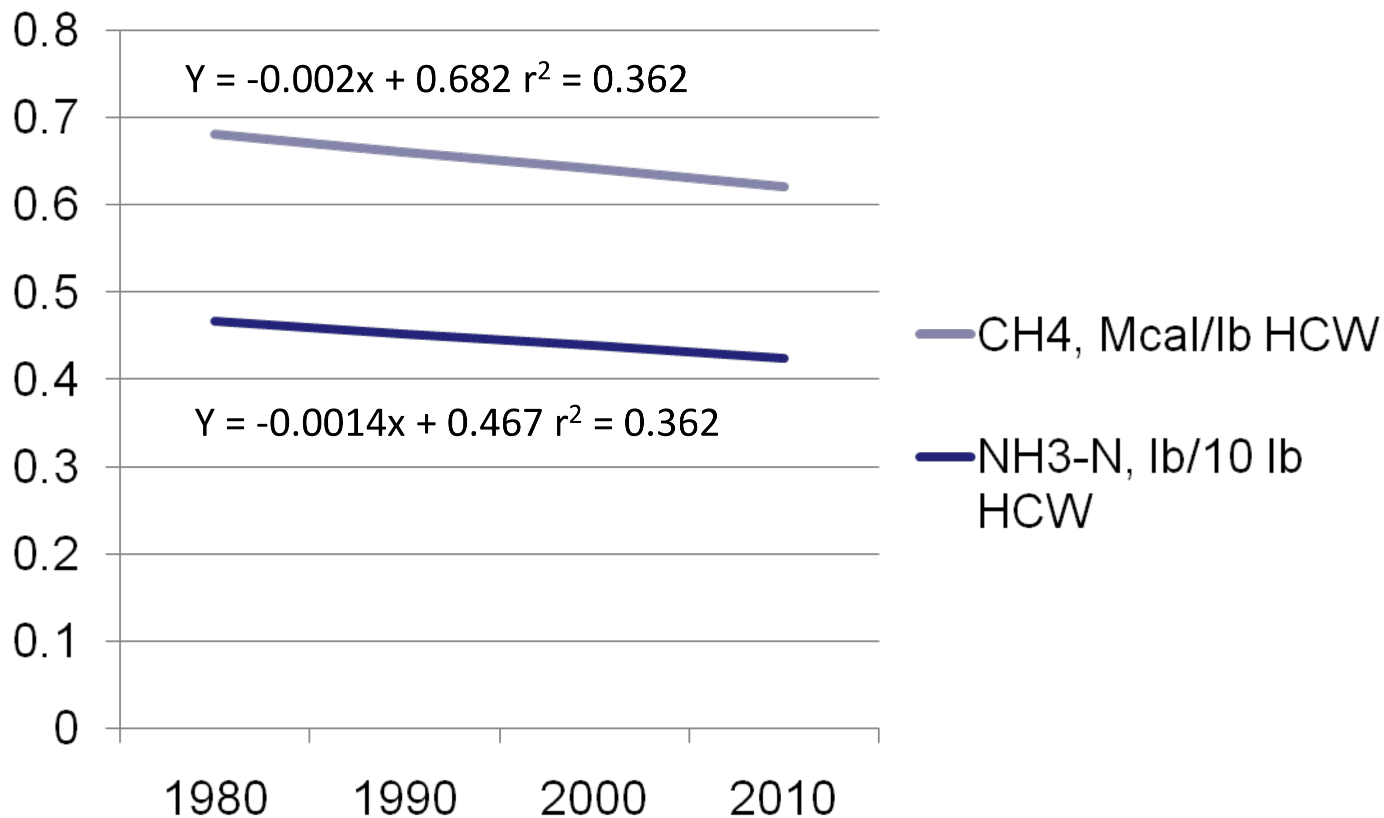
- Diet formulation
- Grain processing
- Feed bunk management
- Ionophores (monensin, lasalocid)
- Growth promoting implants
- Beta-agonists

Changes in Performance Since 1980



MacDonald and Cole, 2011

Changes in Environmental Effects Since 1980



MacDonald & Cole, 2012

Results of Improved Technology and Management: 30 years

- Carcass weight – 20 to 30% increase
- Daily wt. gain – 17 to 47% increase
- DM intake – 7% decrease to 2% increase
- Feed efficiency – 15 to 25% improvement
- Manure excreted – 30 to 40% decrease
- GHG/ lb HCW – 25 to 30% decrease
- NH_3 / lb HCW – 5 to 15% decrease

Overview

- Background
- Greenhouse gases
- Ammonia
- Odors / volatile organic compounds (VOC)
- Dust / PM
- Progress made
- ***Closing thoughts***

Closing Thoughts

- Cattle feeders have made significant progress
  - Continued progress is required
- For GHG - the cow-calf herd is the 800 lb. gorilla (low reproduction rates)
- Enteric CH_4 of feedlot cattle may be near a practical minimum
- Feeding of ethanol by-products – a 2-headed monster (+ and -)

Possible Opportunities

- Precision feeding
- Phase feeding
- Feed additives & other technologies
- Pen amendments

Challenges

- Cost / Income
  - Short term vs. Long term
- Sustainability
- Feeding of by-products
- Location (weather, topography, etc.)
- Unintended consequences
  - Effects on other emissions / losses

Questions???

N. Andy Cole, PhD, PAS, ACAN
Res. Anim. Sci. / Research Leader
USDA-ARS-CPRL
Bushland, TX
Andy.Cole@ars.usda.gov