Feed Management for Dairy Operations to Reduce Air Emissions

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USDA United States Department of Agriculture

Why do Research on Feed Management-Environment?

Manure management had been included in two legislative initiatives of USEPA

(1) Clean Water Act

Abate phosphorus (P) loss in runoff from agricultural land (focus on manure P management)

(2) Clean Air Act

Abate ammonia and GHG emissions from animal agriculture

Animal agriculture also implicated in global climate change

(focus on CO_2, CH_4 and N_2O)

Research summary points

- **Dairy nutritionists** evaluate dietary impacts on cows

- **Soil scientists (and others)** evaluate dietary impacts on manure chemistry and the environment

Research summary points

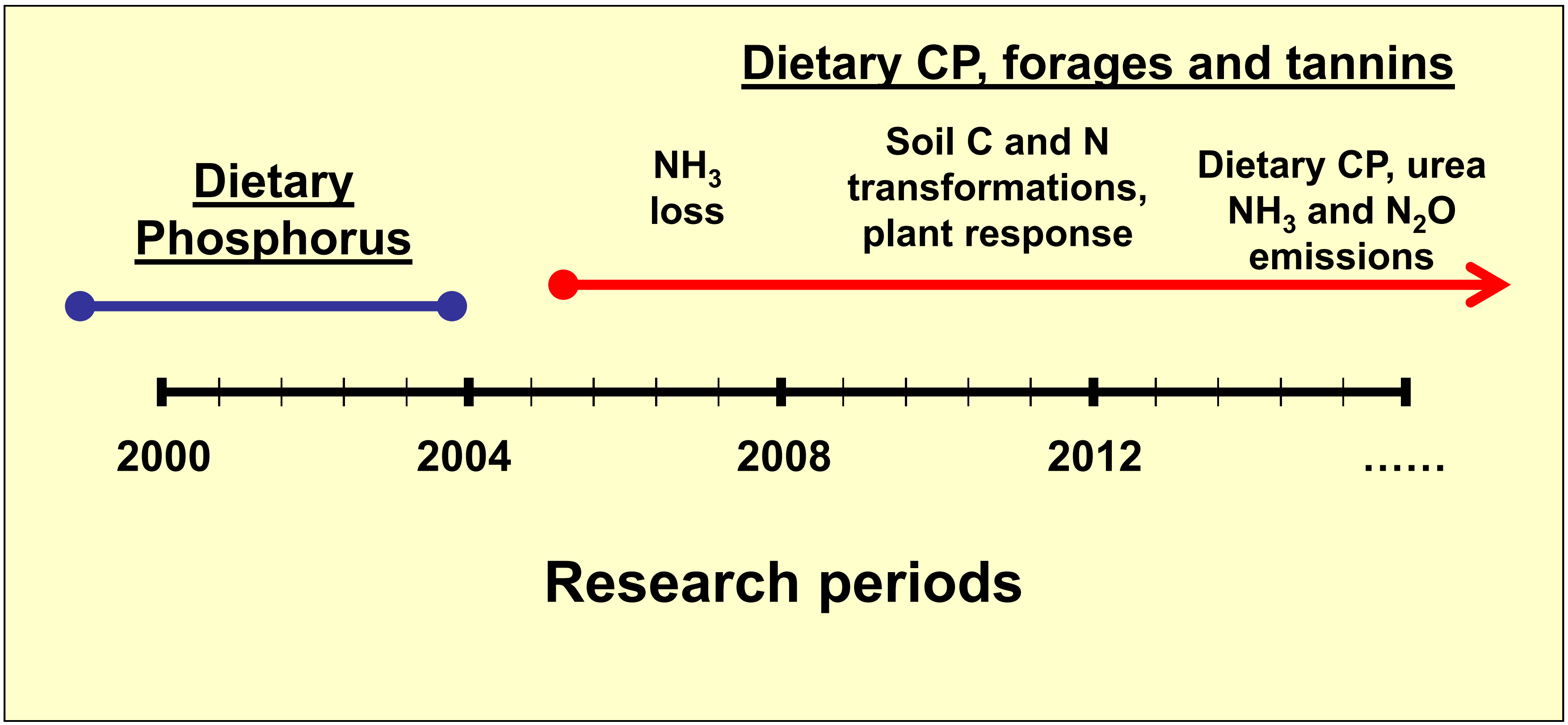
- All lactating cow diets depicted in this presentation are representative of what is fed on confinement dairy farms

- Very few of the tested diets had any significant impacts on milk production (just on manure and the environment)

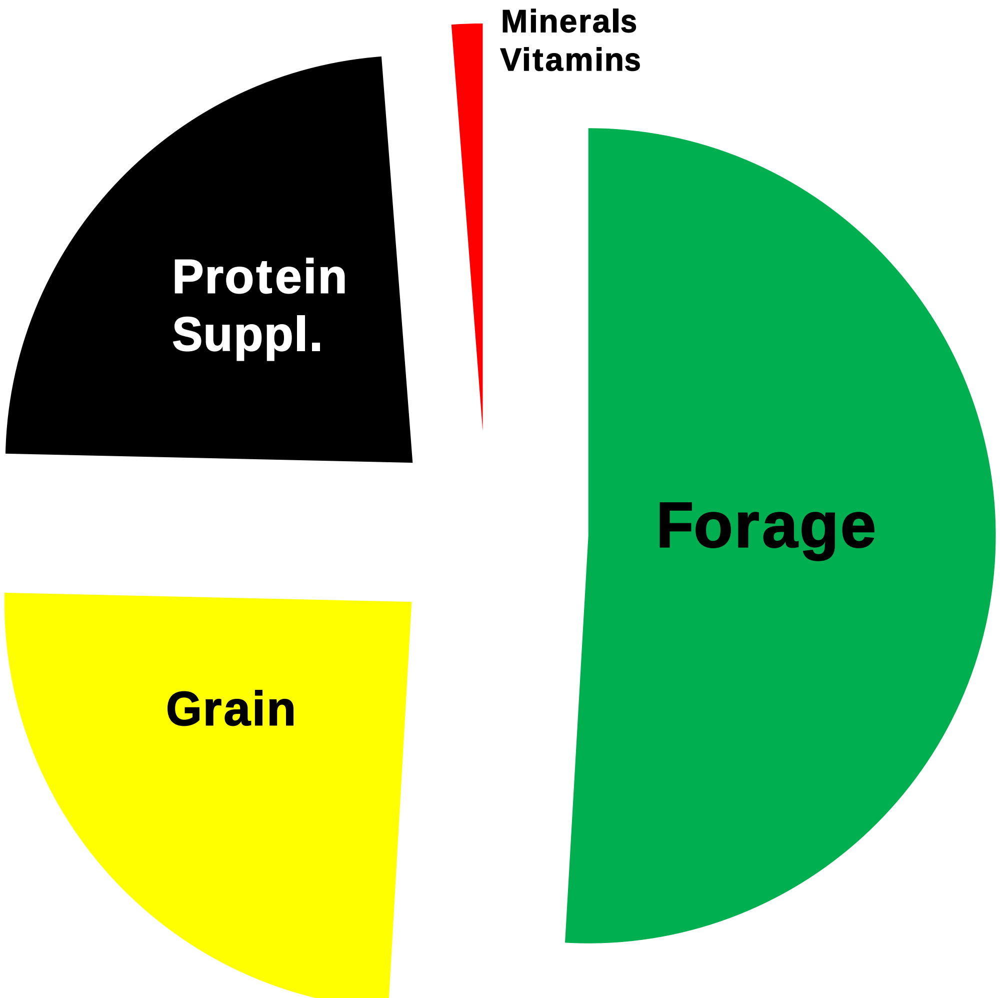
Manure Nutrients and the Environment

Nutrient	*Environmental Implication*
Phosphorus	Runoff (Clean Water Act)
	Leaching (Clean Water Act)
Nitrogen	Ammonia volatilization (Clean Air Act)
	Denitrification (Global Climate Change)
Carbon	Methane emissions (Global Climate Change)
	Soil CO_2 flux (Global Climate Change)

Chronology
Dairy Nutrition – Environmental Research



Some dairy ration impacts on manure chemistry

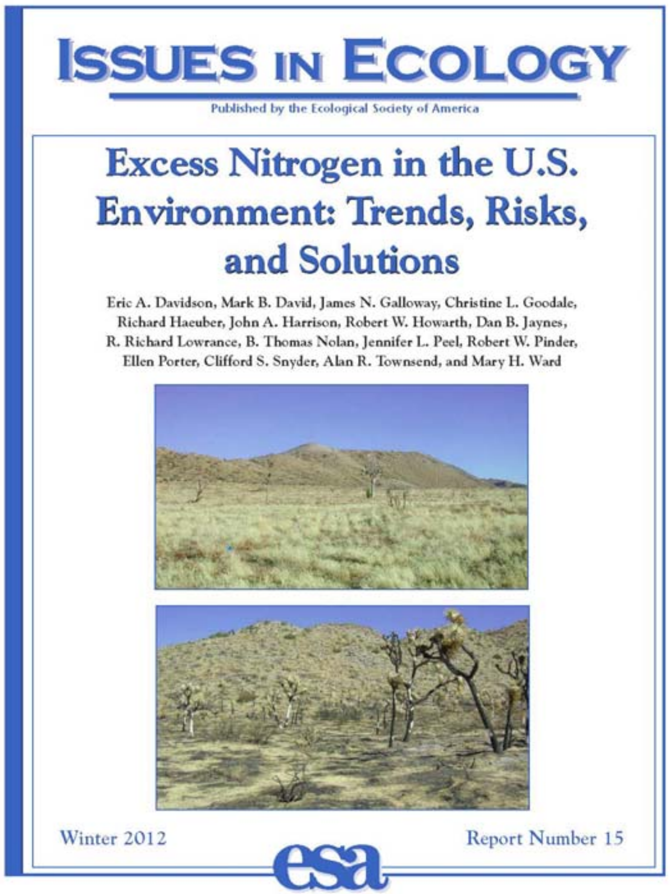


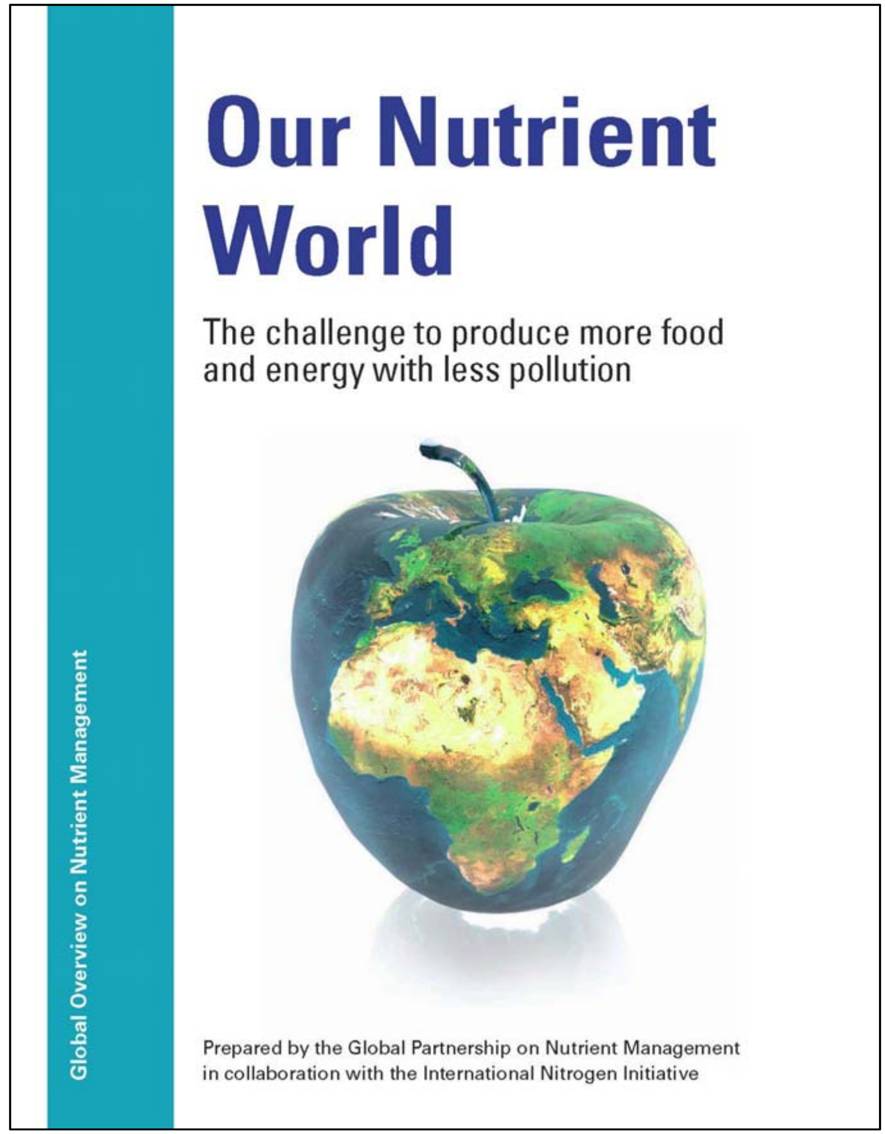
Phosphorus
Fecal P
Fecal soluble P

Nitrogen
Fecal N: Urinary N ratio
Fecal endogenous N
Fecal fiber N
Urinary urea N

Carbon
Fecal structural CHO
Fecal Non-structural CHO

Nitrogen and the Environment



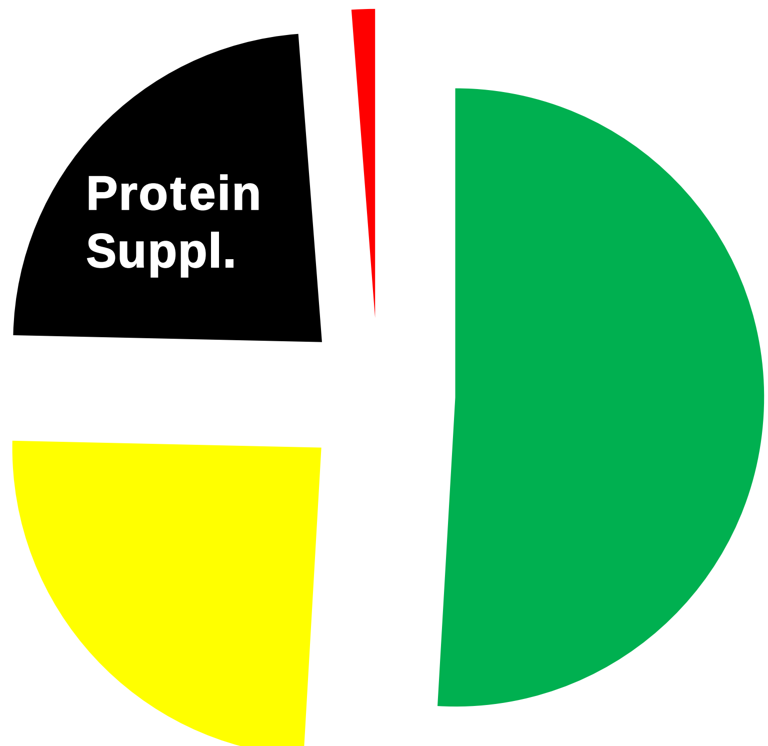


The dietary CP story

(A response to air quality legislation and global climate change)

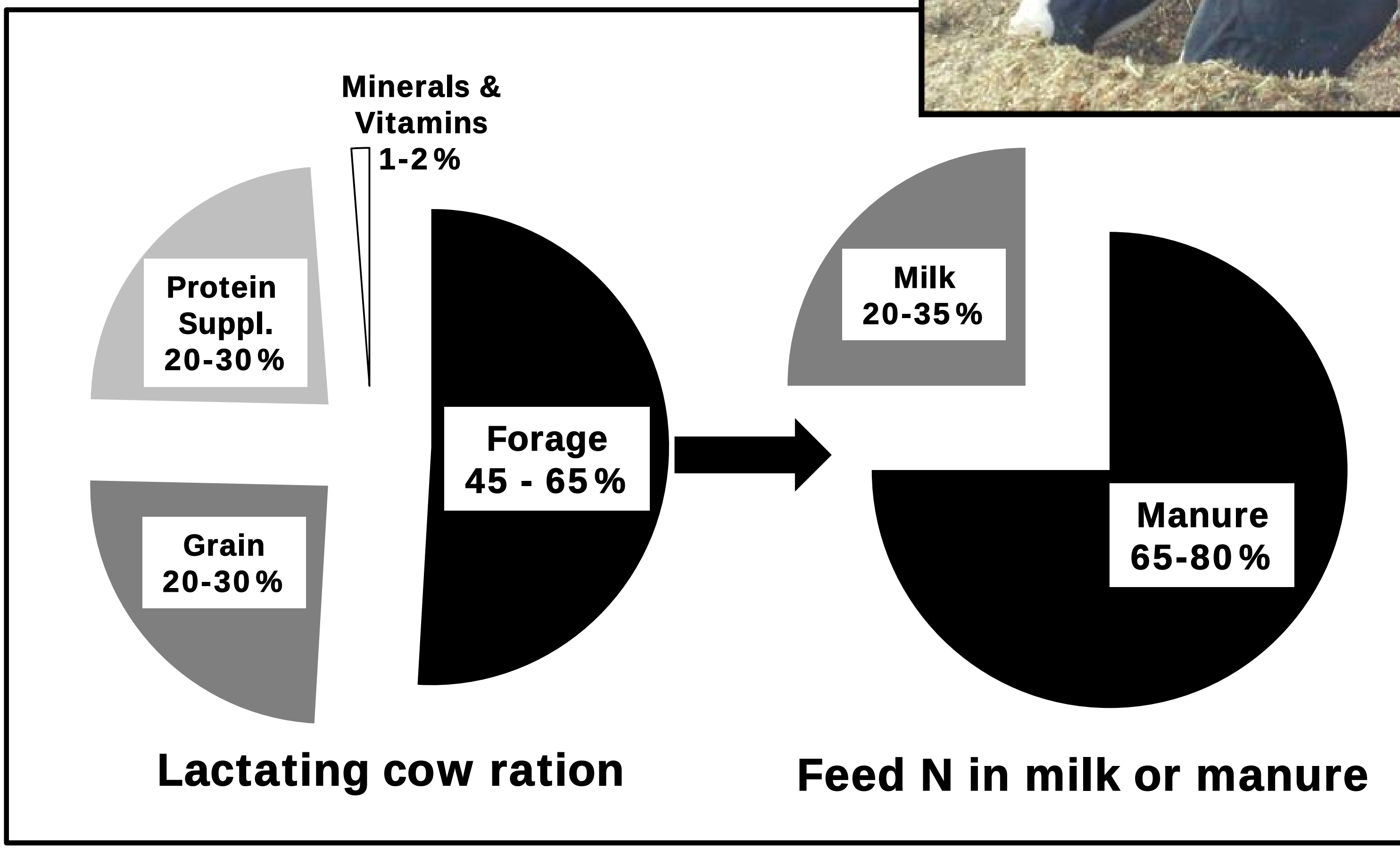
Impacts of diet CP level and form

- Fecal N: Urinary N ratio
- Urinary urea N
- Ammonia emissions
- Nitrous oxide emissions
- Fecal N mineralization in soil
- Plant N uptake



Lactating Cow Diets and Feed N Use

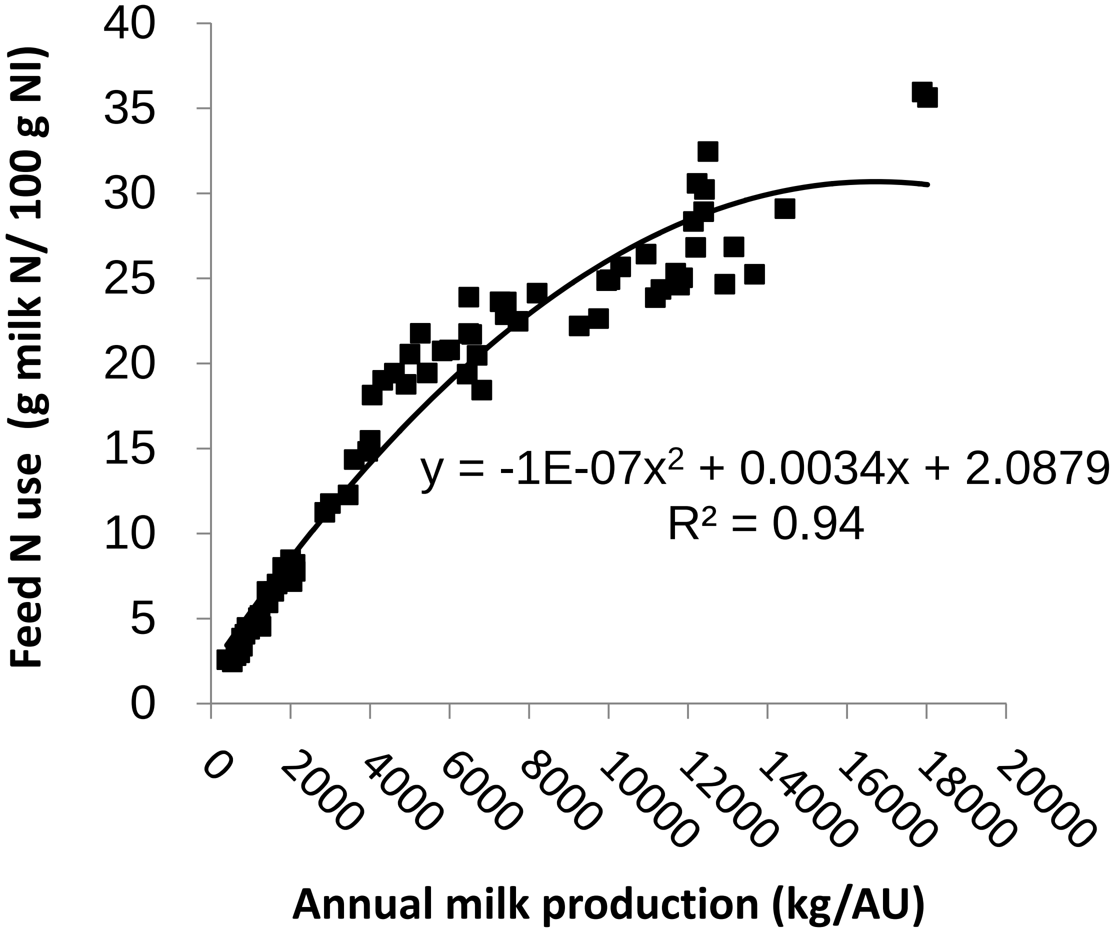
(confinement dairy farms)



Range of feed N intake and feed NUE on dairy farms in USA

Feed N intake (g/cow/day)	Feed NUE (%)	Source
750 to 200	21 to 32	Castillo et al., 2000
628 to 289	22 to 29	Kebreab et al., 2001
897 to 496	21 to 36	Chase, 2004
666 to 512	26 to 33	Powell et al., 2006

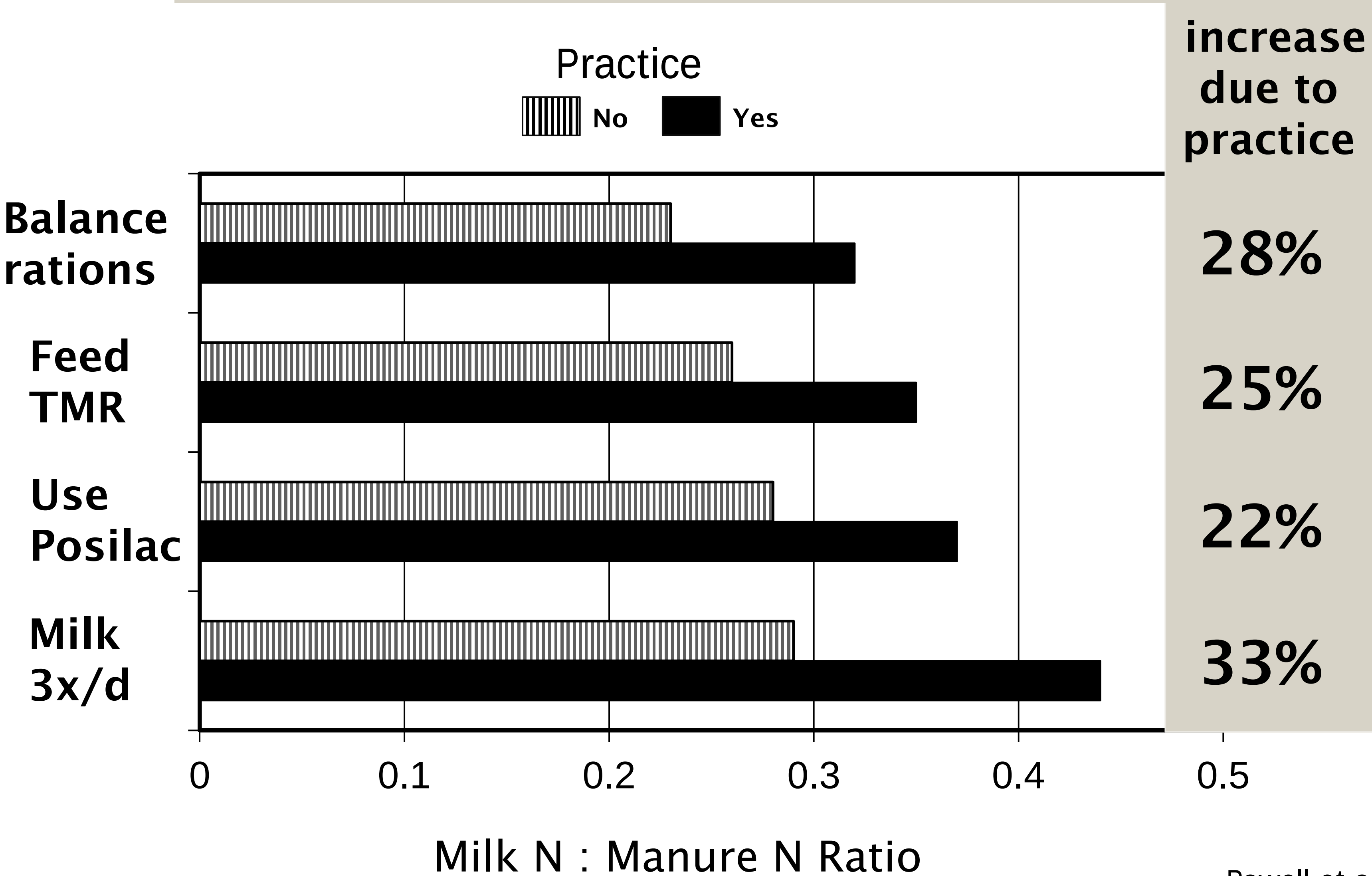
Relationship between milk production and feed N use
(n=142 countries)



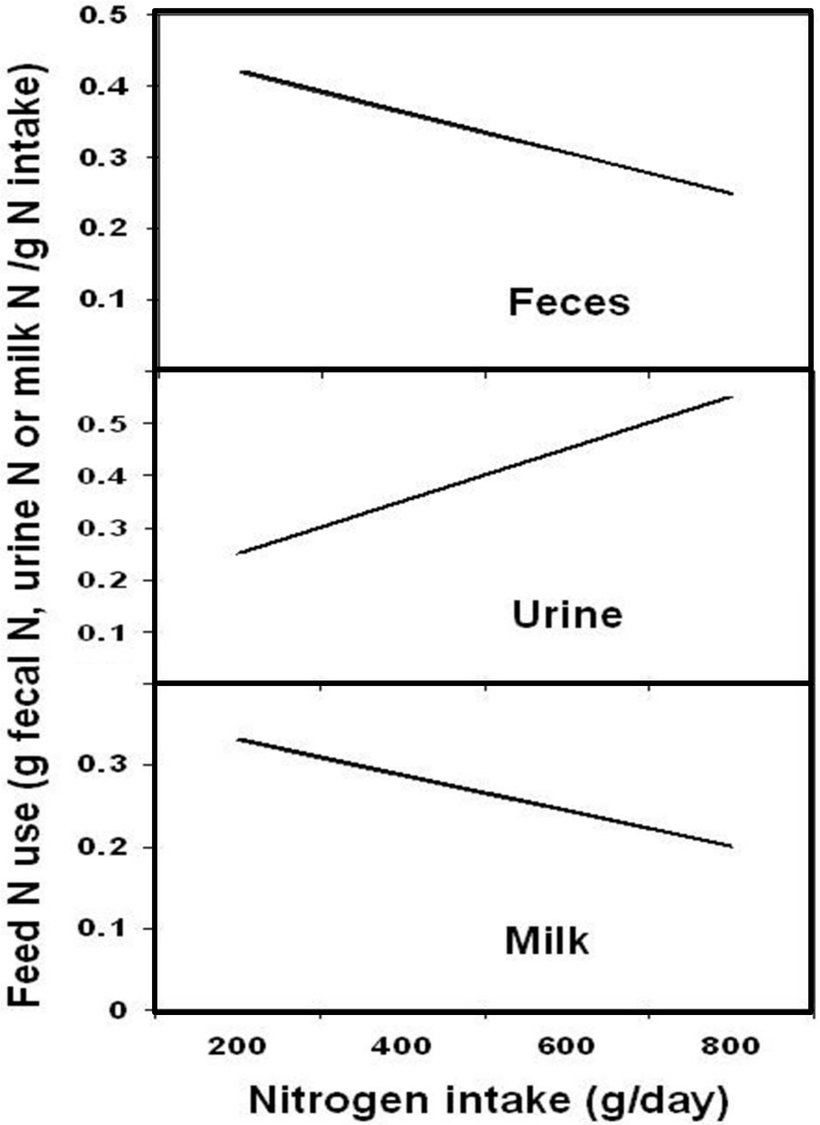
Powell et al., 2013

Milk N: Manure N ratios

(54 Wisconsin dairy farms)



Powell et al., 2006



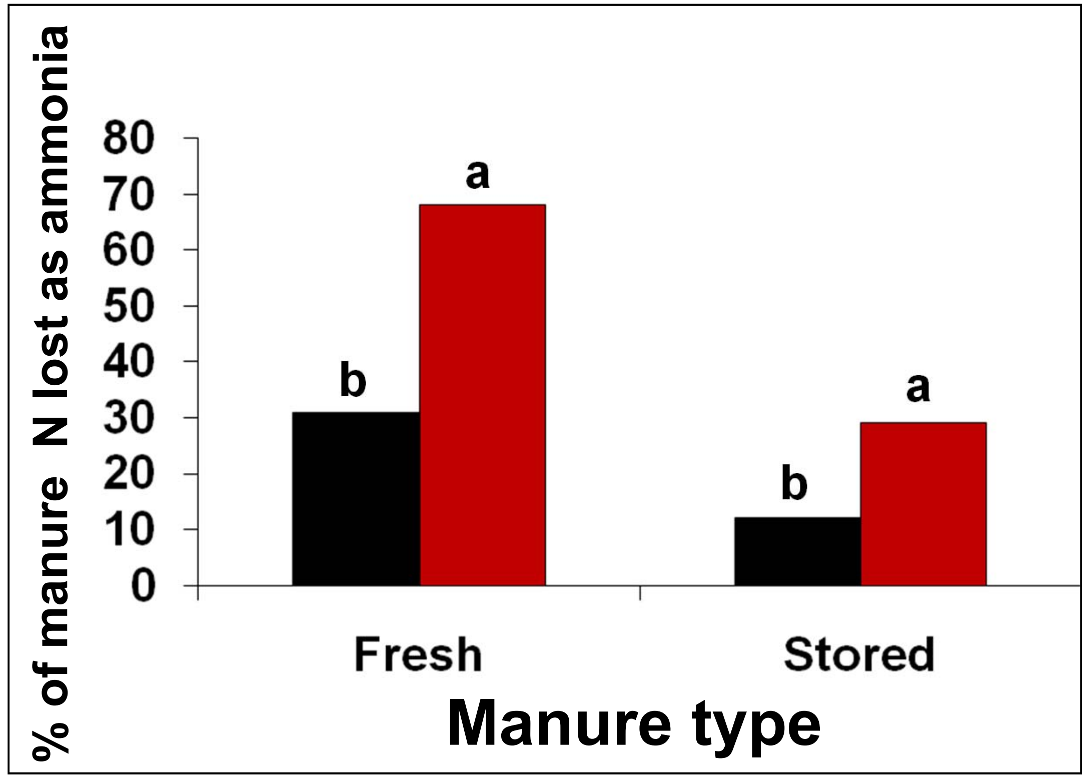
As N intake exceeds requirement, feed N use declines & urine N excretion increases

Castillo et al., 2000

Excess dietary CP increases manure N and urine N excretions

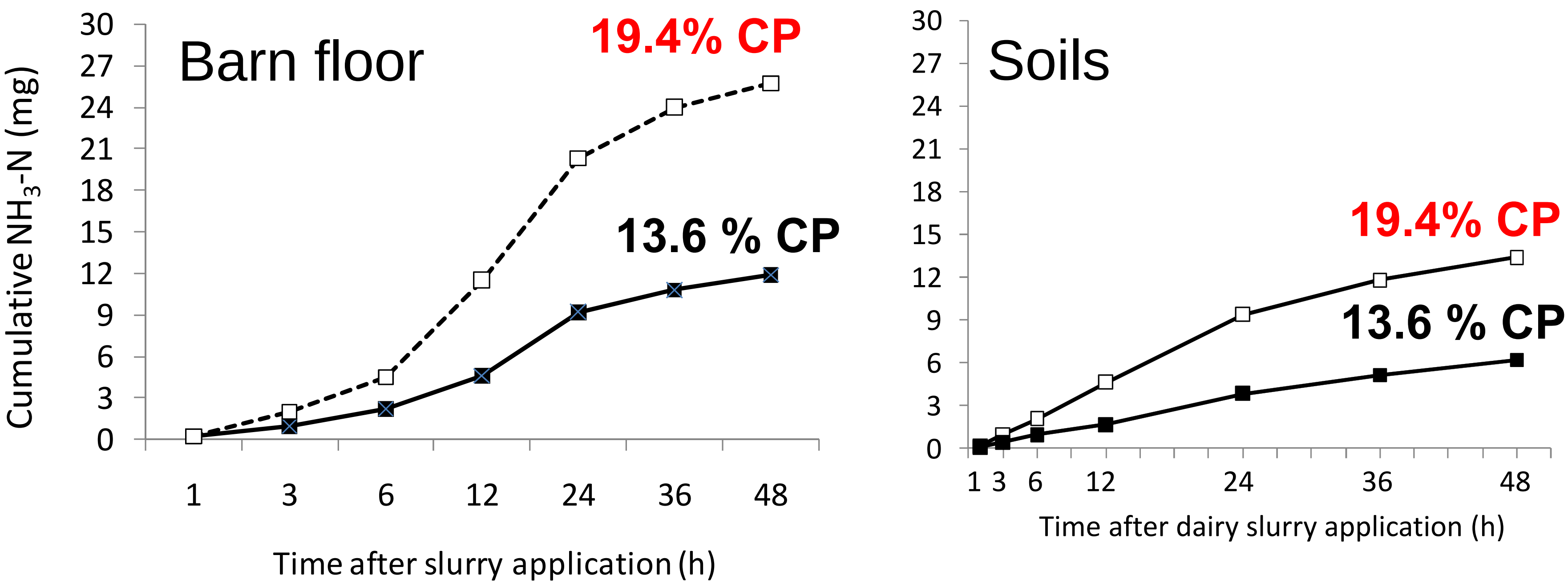
	13.6% CP	19.4% CP
Manure N g/cow/d	222	314
% Urine N	52	68
% Fecal N	48	32

….and also ammonia emissions after manure land application



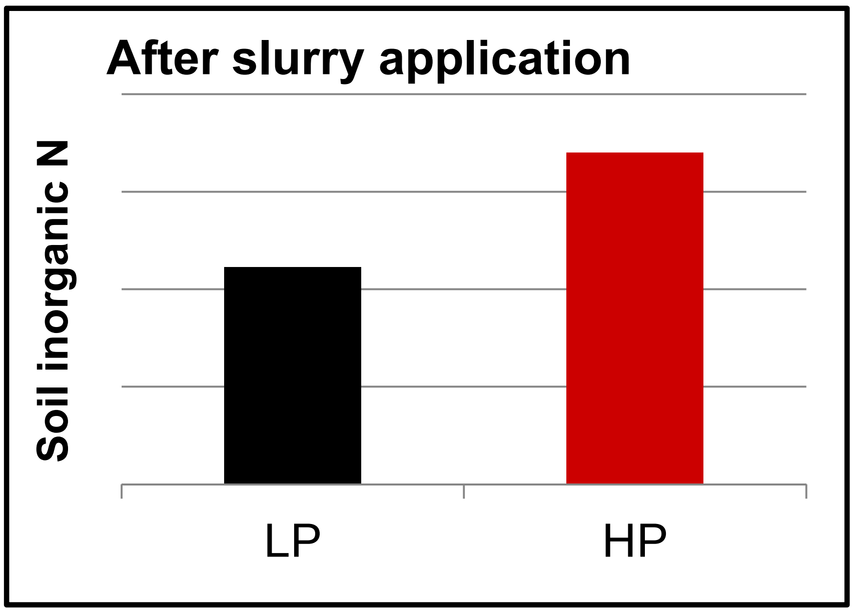
Misselbrook et al., 2005

Dietary CP impacts urinary urea N excretion and NH_3 emissions



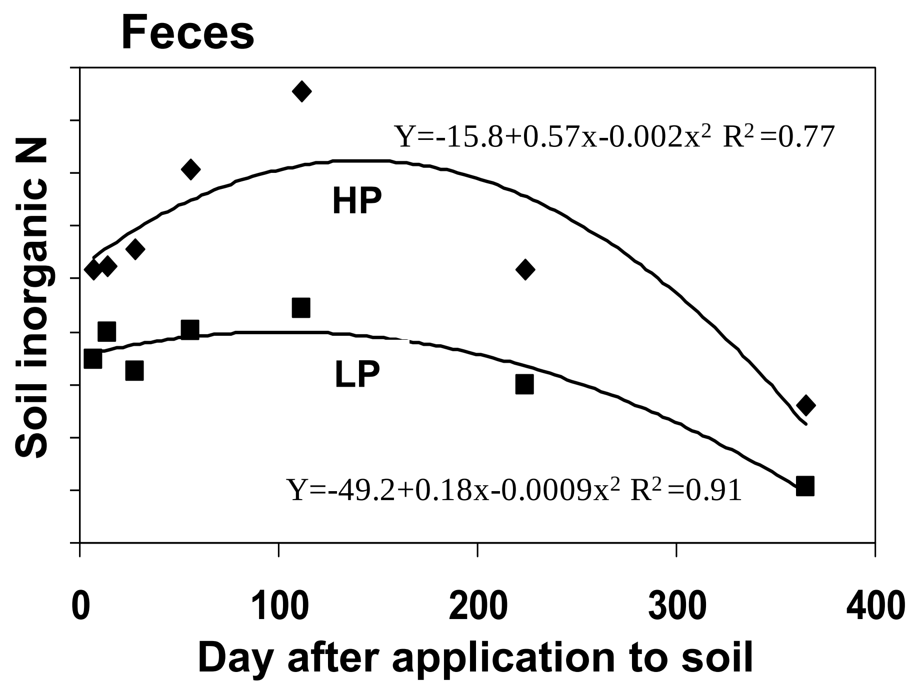
Misselbrook et al., 2005

TRADEOFF?
Ration CP impacts ammonia loss but also manure N availability to plants



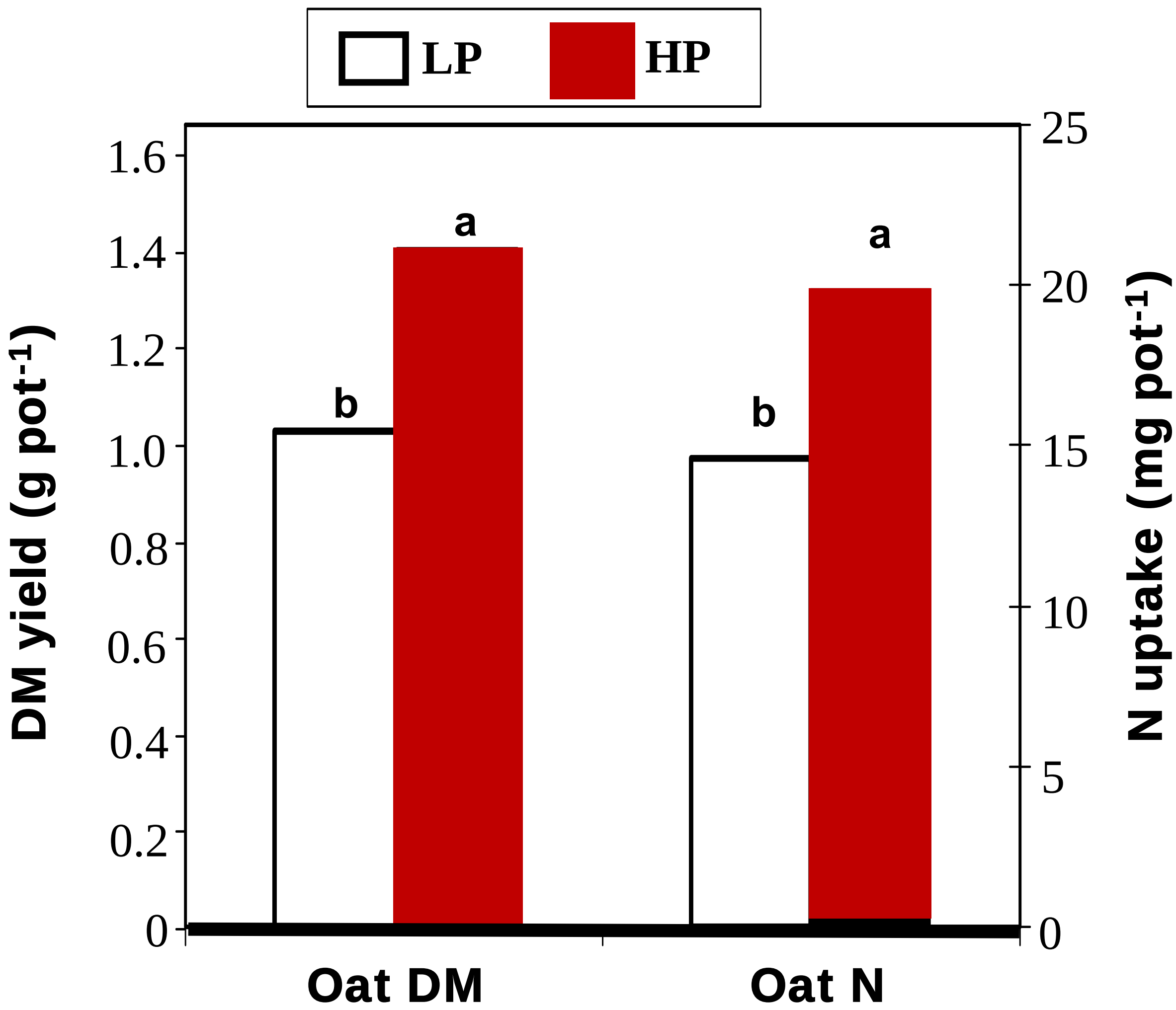
After cessation of NH_3 volatilization (48h)

Powell et al., 2011



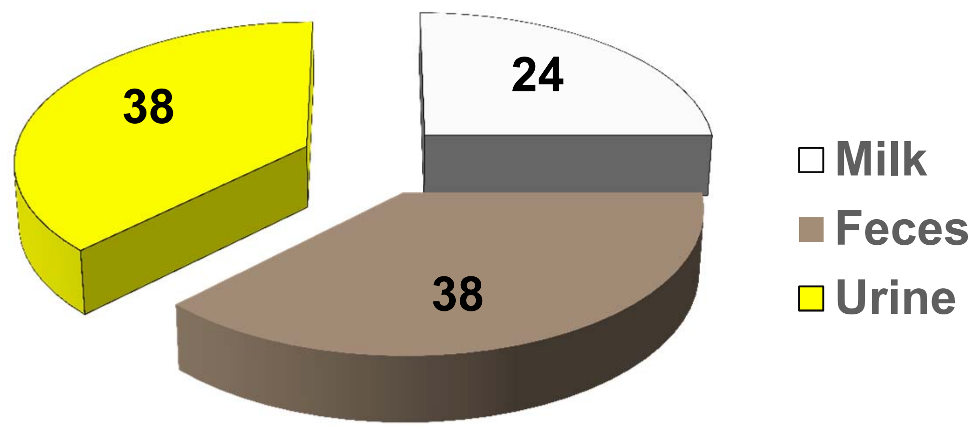
Powell et al., 2006

……and crop yield and N uptake



Powell et al., 2006

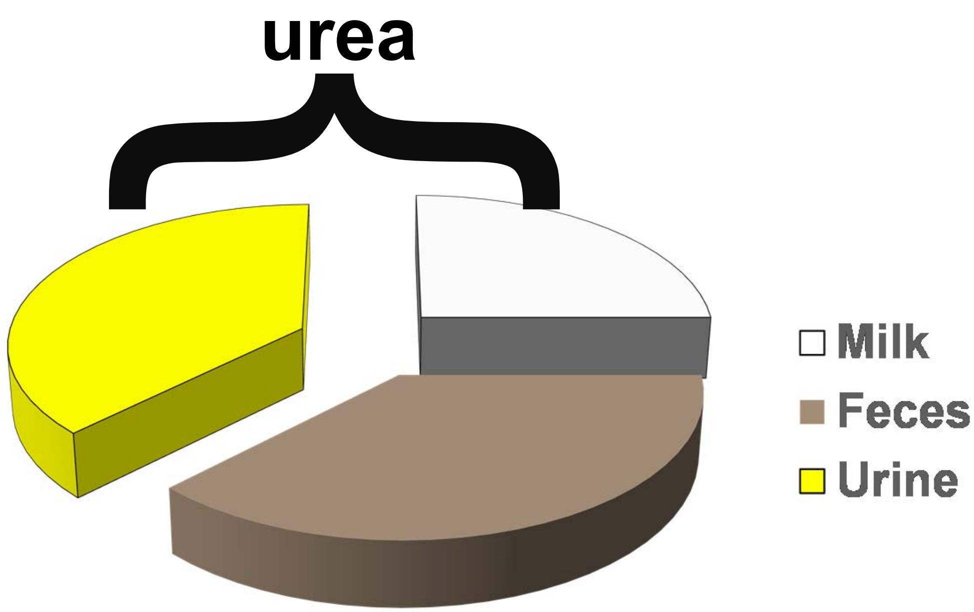
Partitioning Feed N Intake (%)
(typical confinement dairy farm)



Urine is greatest source of N_r on dairy farms

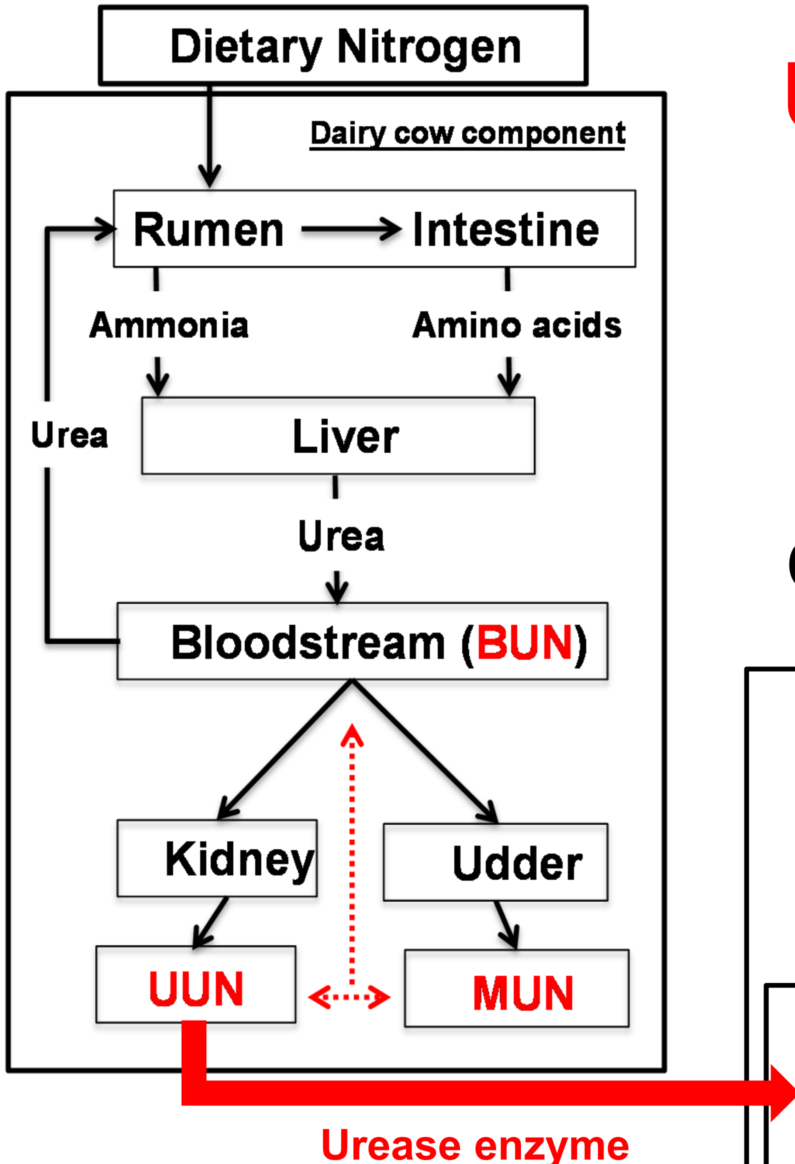
How much feed N is consumed?
How much urinary N is excreted?

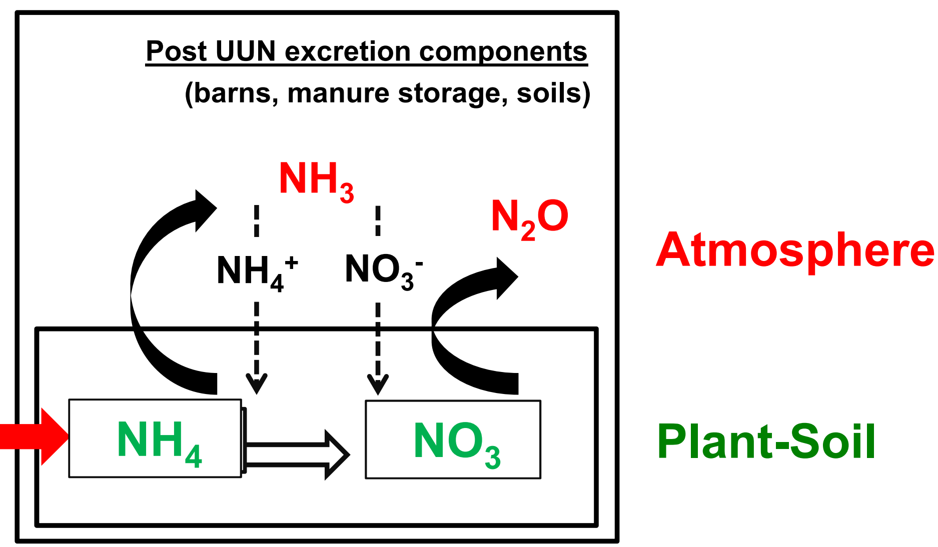
These can be determined using milk urea N (MUN)



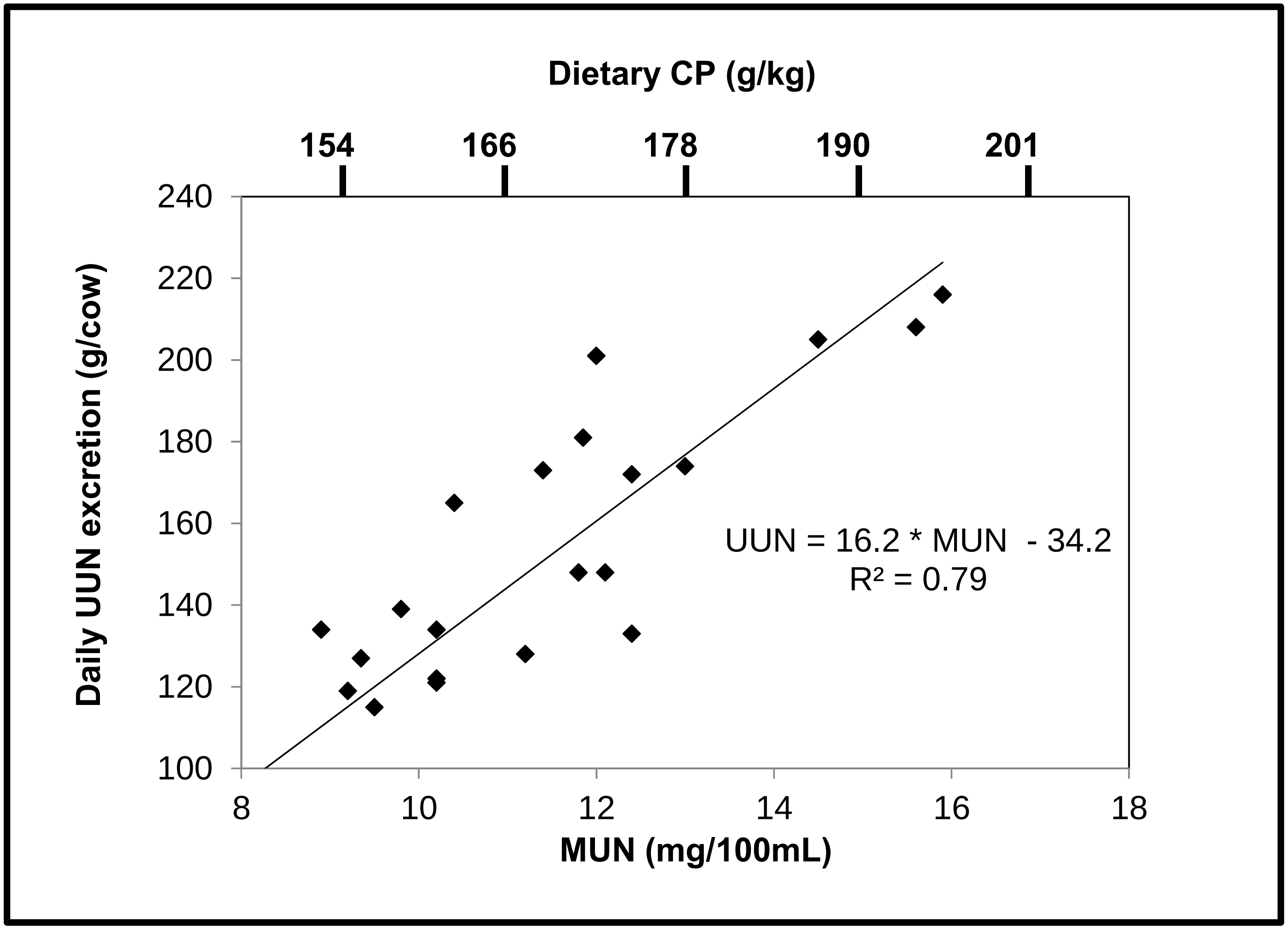
Urinary urea N

Greatest N_r source on dairy farms





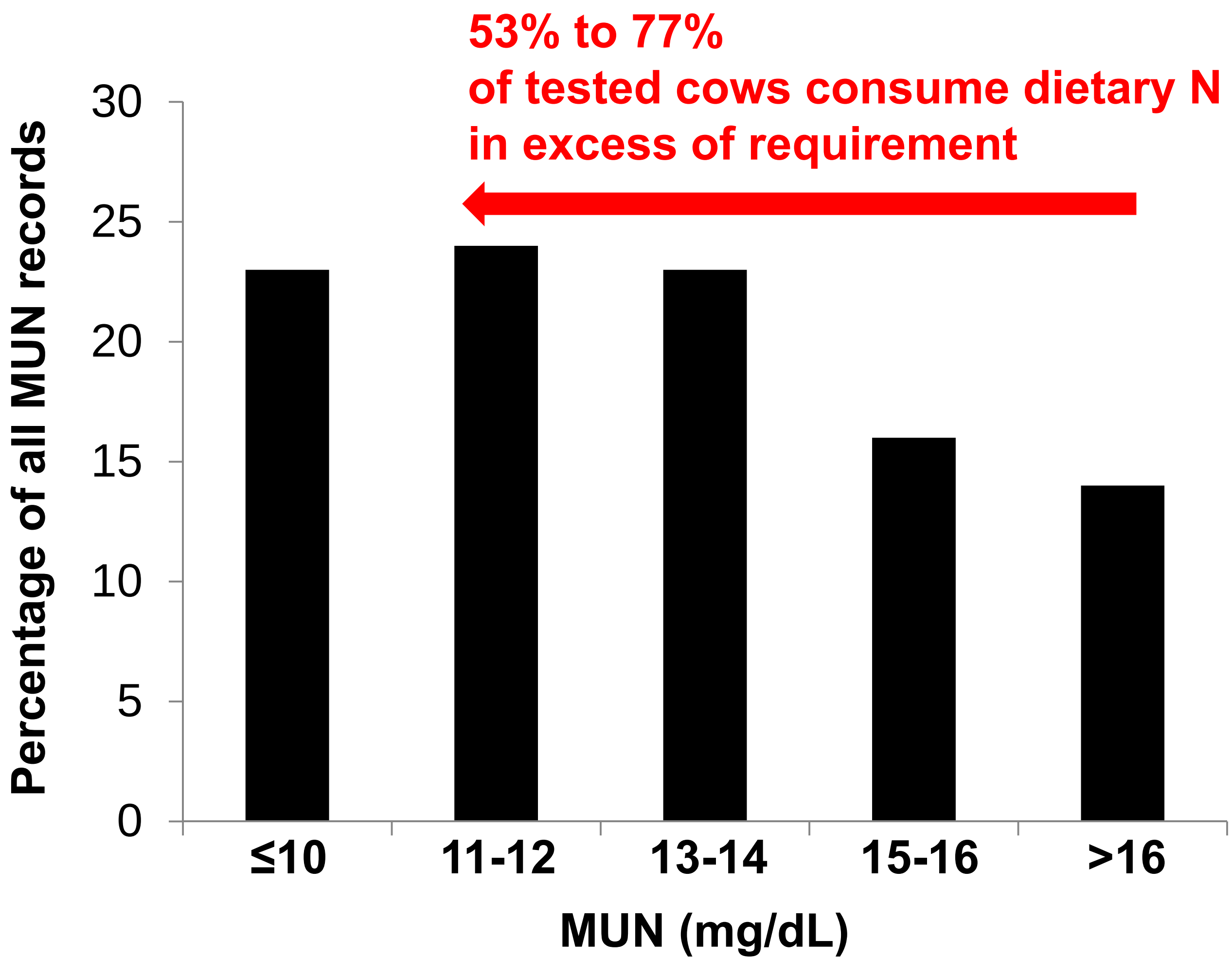
Dietary CP, MUN and UUN



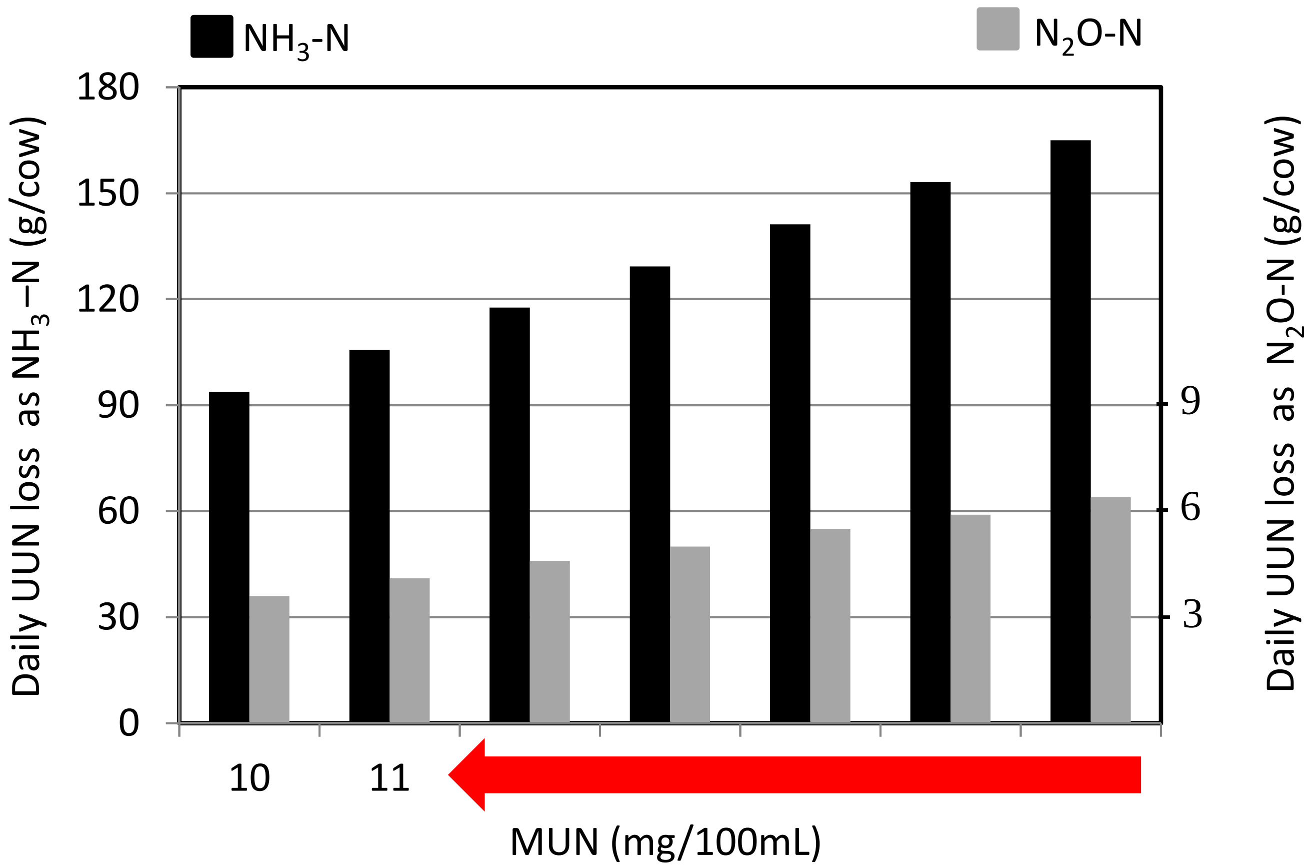
Wattiaux et al., 2011

Distribution of MUN
Wisconsin Dairy Farms

(37,889 cows in 197 herds)



MUN, UUN and N emissions Wisconsin dairy farms



Feeding to achieve MUN 12 to 10 mg/dL

Would reduce: NH_3 **emissions by 35 to 42%**

N_2O **emissions by 18 to 21%**

Use of milk urea N (MUN) to track NH_3 emission from dairy farms

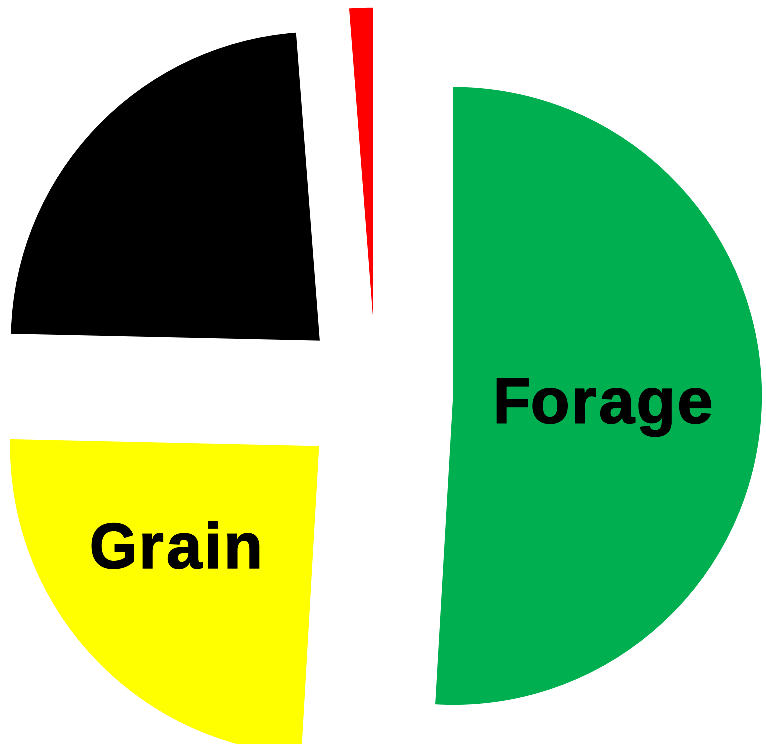
Location	Barn type	MUN (mg/dl)	NH_3 emissión (g/cow/d)	Percent NH_3 reduction (from base MUN of 14 mg/dl)
Wisconsin	"Stanchion"	14	14.2	0
		10	10.2	28%
Wisconsin	"Free stall"	14	77.2	0
		10	51.2	34%
California	"Free stall"	14	95.4	0
		10	75.3	21%
The Netherlands	"Stanchion"	14	28.2	0
		10	22.3	21%

Powell et al., 2011

Forage : Grain Story

Forage
Grain
} Ratio

• Methane emissions



Major greenhouse gases (GHG) produced on dairy farms

Methane (CH_4)

enteric fermentation by cows
manure storage
silage bunkers and piles

Nitrous oxide (N_20)

(released from soil)

fertilizer on crops
manure on crops
manure on pastures

Carbon dioxide (CO_2)

energy use on farm, in field
production of N fertilizer

Volatile organic compounds (VOC)

silage bunkers and piles

Ammonia (NH_3)*

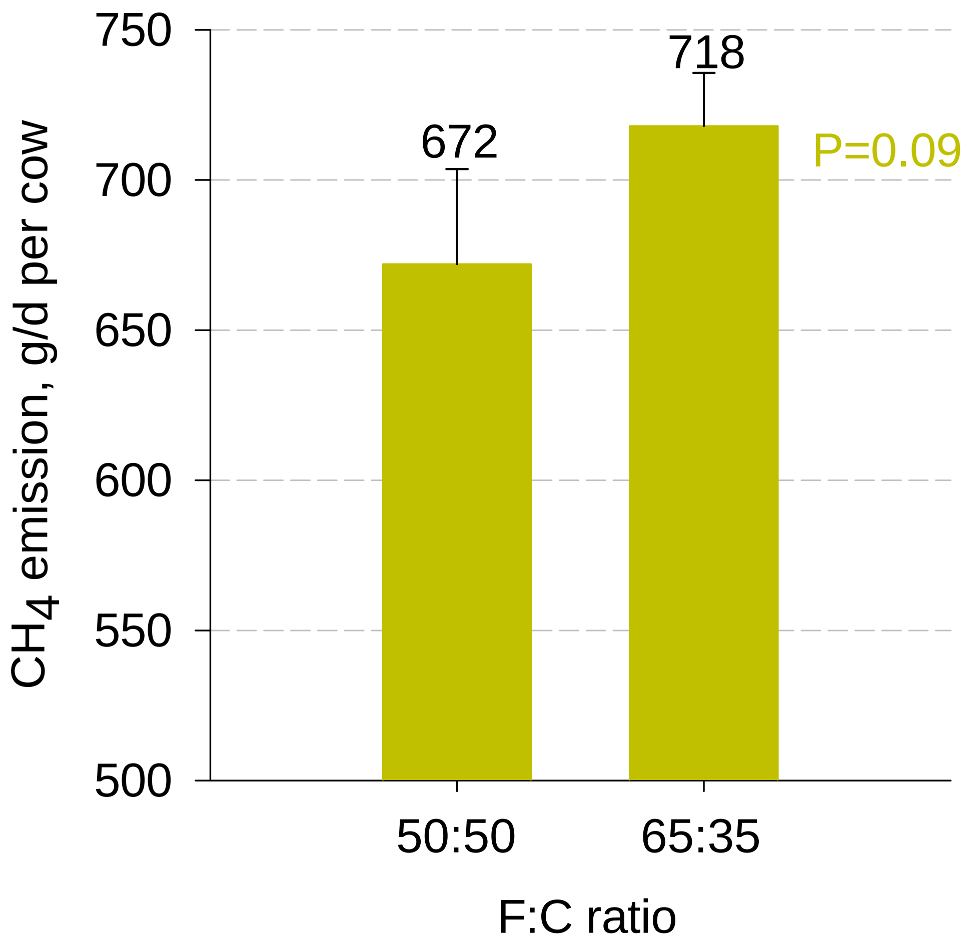
manure in barns and storage
silage bunkers and piles
soils

* Not a GHG, but emissions can be regulated

WHICH END
of a dairy cow produces more
GAS?

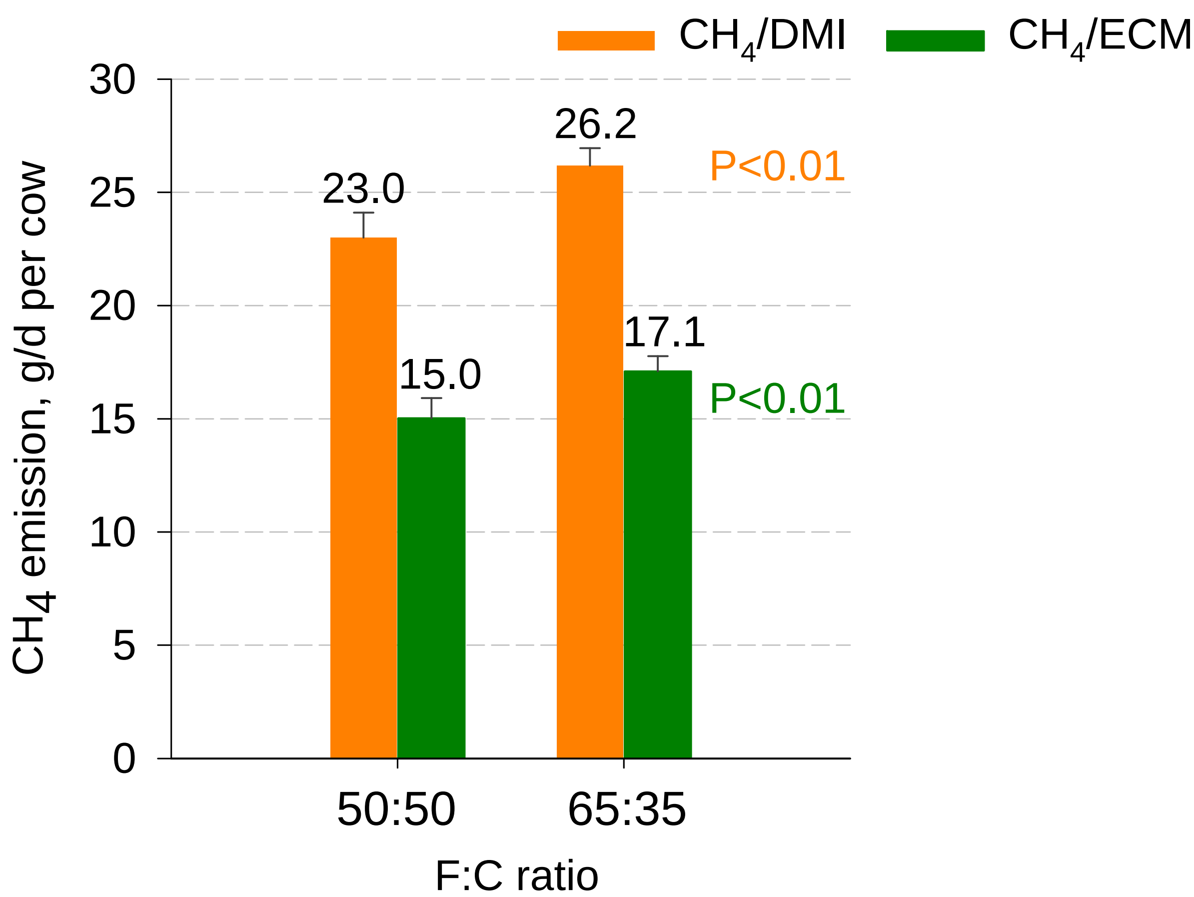
The FRONT end!
Methane source is
95% belching
(burps)
5% flatulence
("toots")

Effect of Forage:Concentration Ratio on Daily CH_4 emission



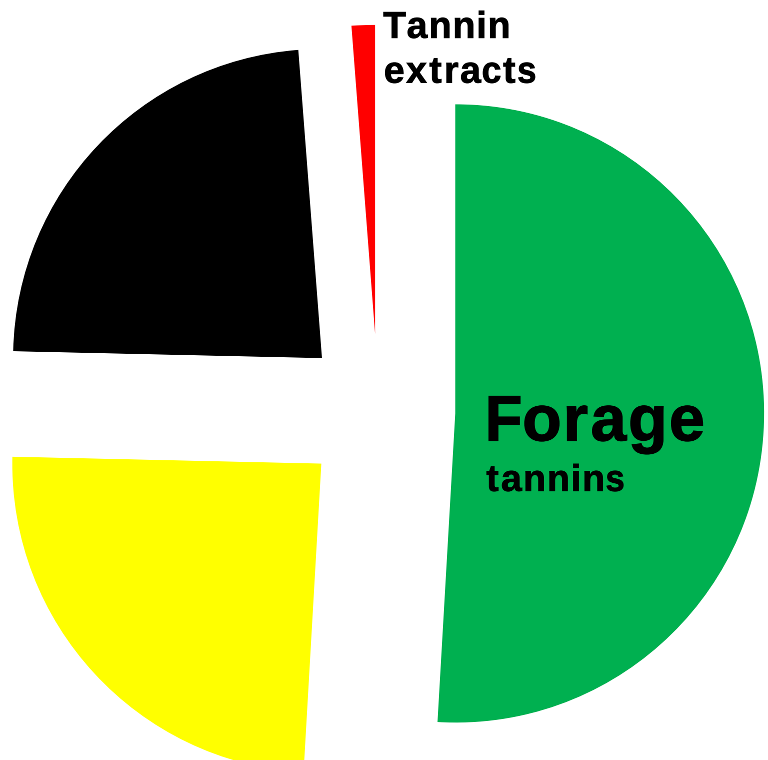
Aguerre et al., 2013

Effect of Forage:Concentrate Ratio on CH_4 emission per unit of DMI and ECM



Aguerre et al., 2013

The tannin story



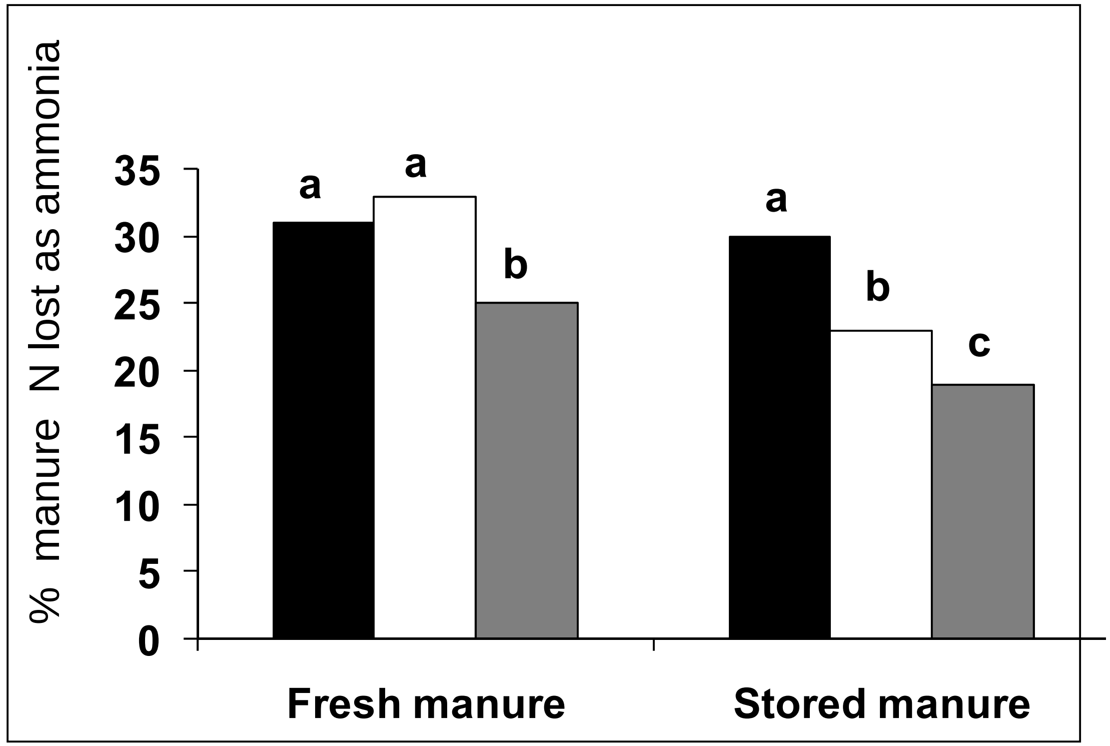
Dietary tannins

- decrease urinary N
- decrease urease activity
- decrease NH_3 emissions

Forage tannins reduce urine N excretion

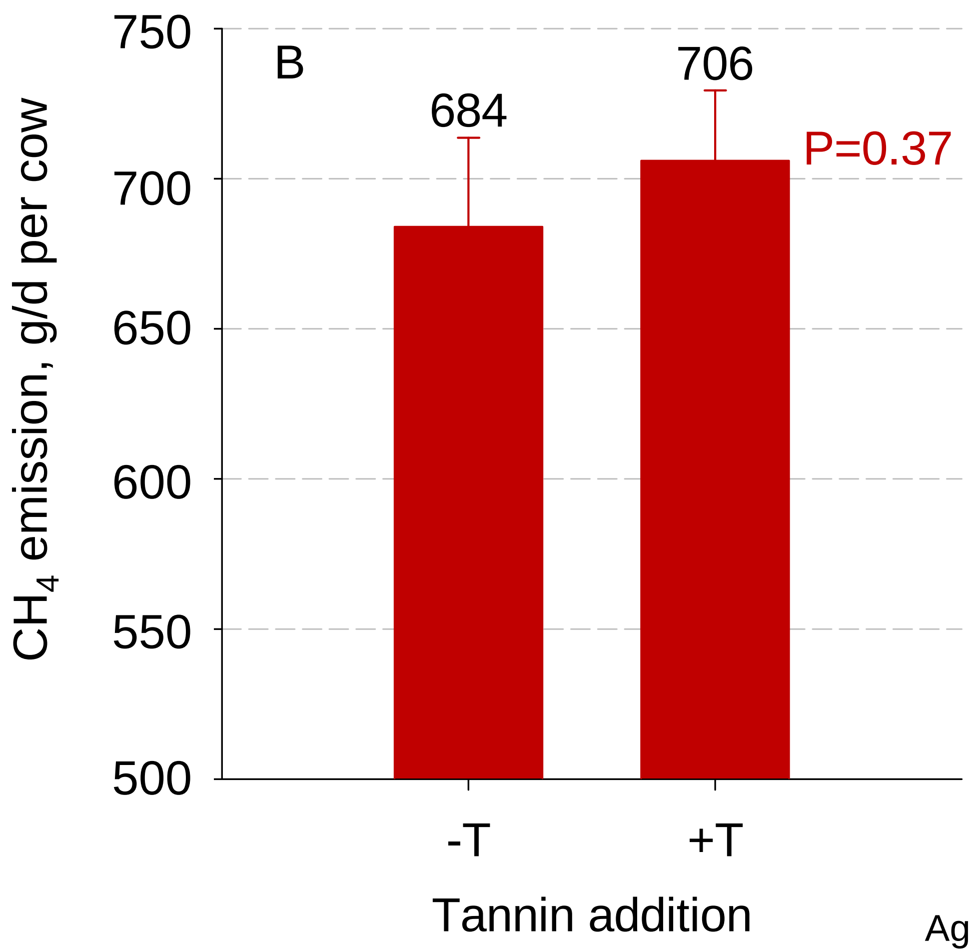
	Alf	BF-T-Low	BF-T-High
Manure N g/cow/h	12.3	15.8	17.1
% Urine N	55	60	40
% Fecal N	45	40	60

….and ammonia emissions after manure land application



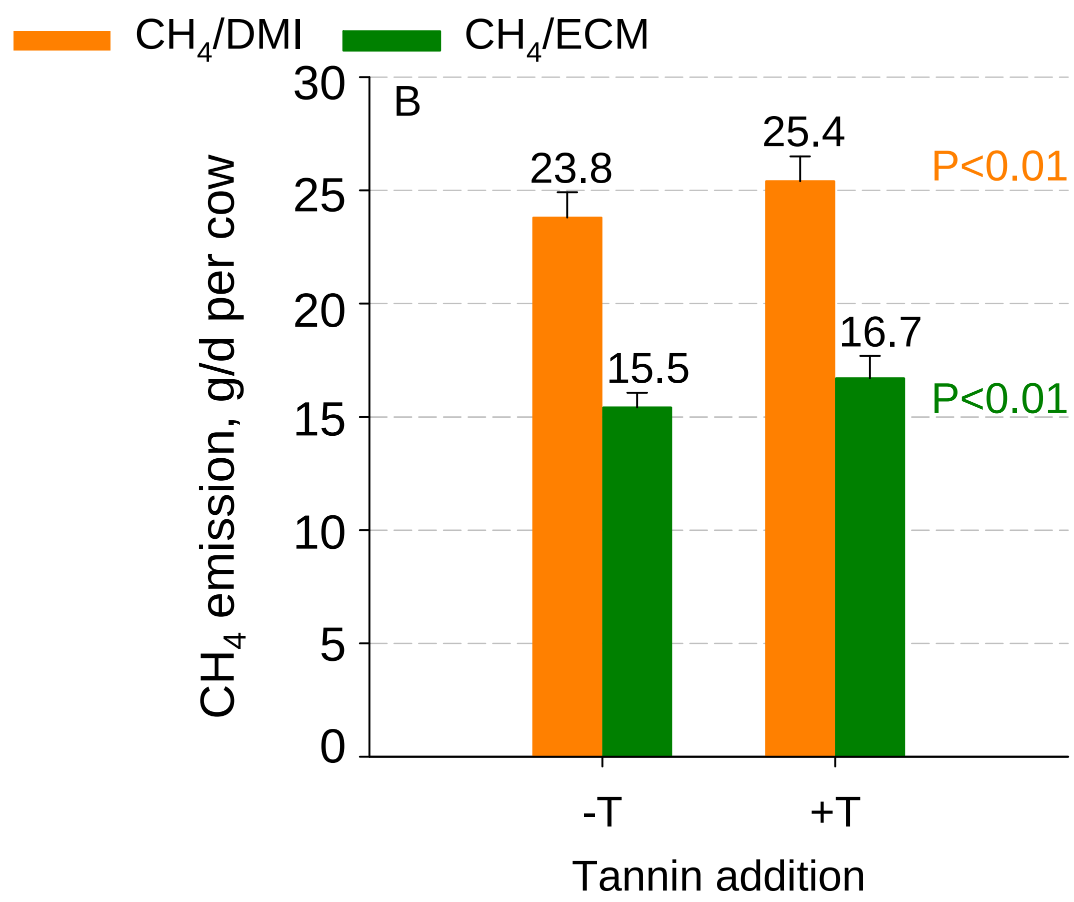
Misselbrook et al., 2005

Effect of Feeding a Tannin Extract on Daily CH_4 Emission (tradeoff?)



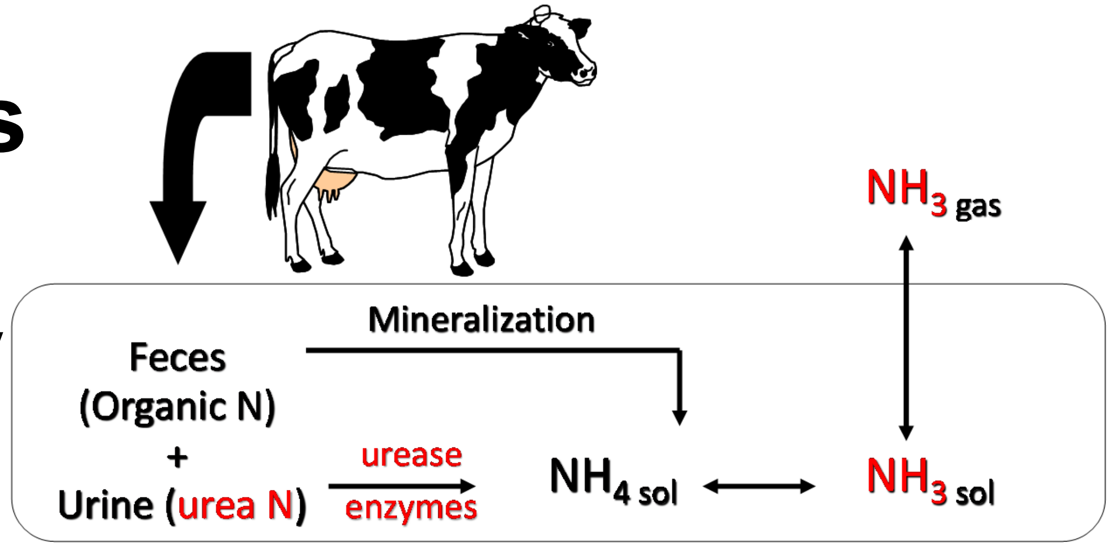
Aguerre et al., 2013

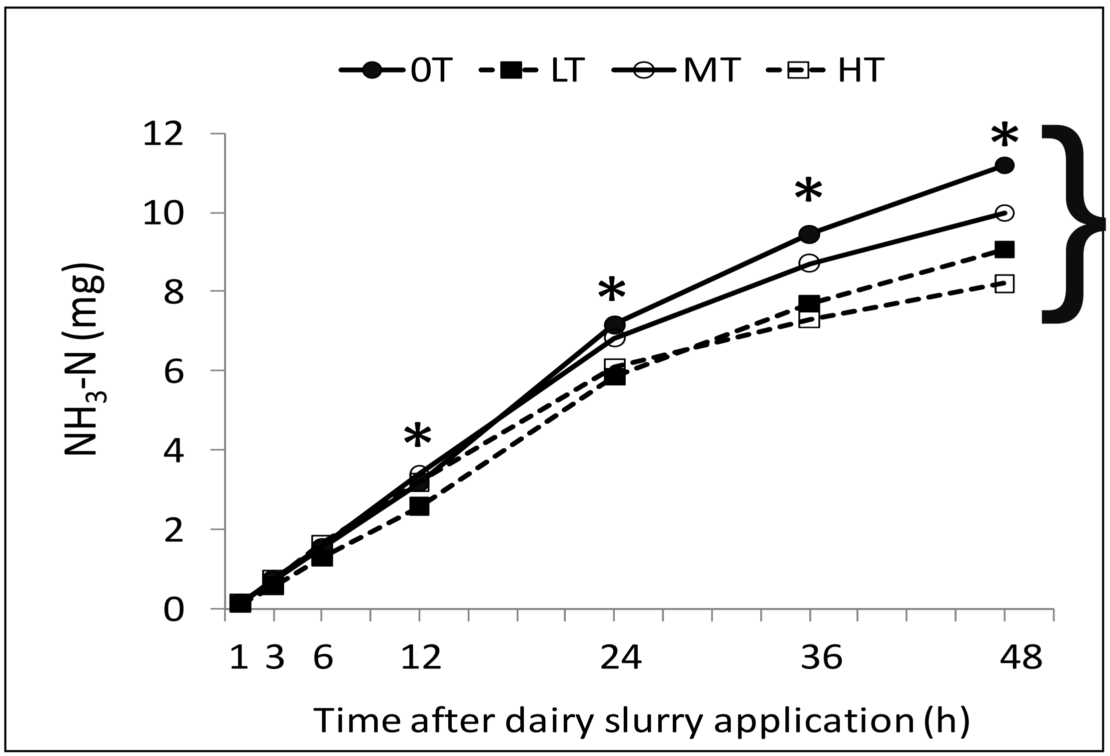
Effect of Feeding a Tannin Extract on CH_4 emission per unit of DMI and ECM (tradeoff?)



Aguerre et al., 2013

Dietary Tannins Decrease Urease Activity in Dairy Feces



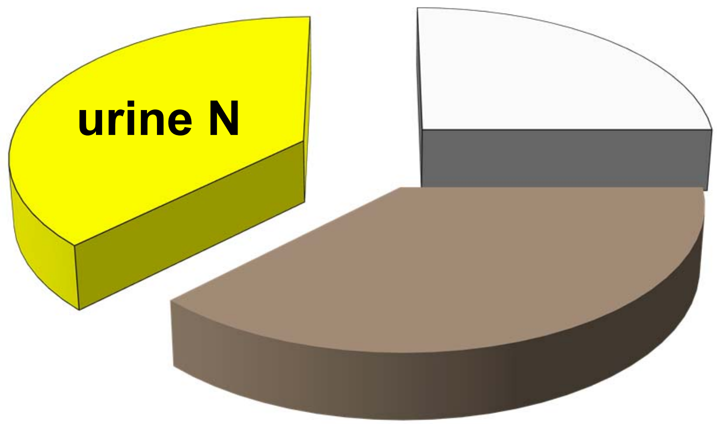


11-19% reduction in NH_3 emission due to decrease in urease activity

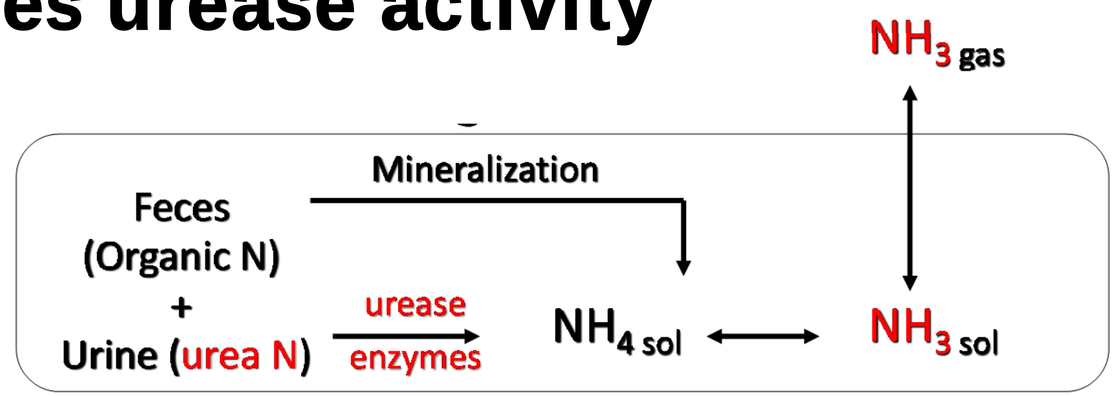
Powell et al., 2011

Feeding Tannins

1) reduces urine N



2) reduces urease activity



Summary

- What we feed to cows impacts NH_3, N_2O and CH_4 emissions from dairy farms
- Excess dietary N is excreted as urea in urine and this increases NH_3 and N_2O emissions
- Dietary N, urea N and NH_3 emissions can be monitored using milk urea N (MUN)
- Reduction in dietary CP may reduce fertilizer N value of manure (tradeoff)

Summary

- The addition of tannin to cow diets reduces urea N in urine, urease activity in feces and NH_3 emissions

- Although tannins may enhance N use, it may increase CH_4 emissions (tradeoff)

Summary

- Dairy rations can be formulated to satisfy the nutrition requirements of healthy, high producing cows while producing manure less susceptible to gaseous N loss

- These are win-win strategies that enhance feed use, and reduce gas emissions and overall environmental impacts of milk production

Thanks
For
Your Attention!