USDA United States Department of Agriculture

Nitrogen use and trade-offs on dairy farms: An illustration of complexity

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What complexity?

- Biological systems are limited in N use
- Major portions of agricultural N inputs are lost to the environment
- Nitrogen loss pathways are diverse
- There are tradeoffs in N use, N conservation and N loss

Outline



1. Nitrogen use efficiency (NUE) in dairy production
   a. Whole-farm NUE
   b. Feed NUE
   c. Manure NUE
2. Trade-offs in N use, N conservation and N loss
3. Summary points

1. Nitrogen use in dairy production

Nitrogen Input → **Nitrogen Product** { **1. NUE** **2. N balance**

Scales

- Farm components
- Whole-farm

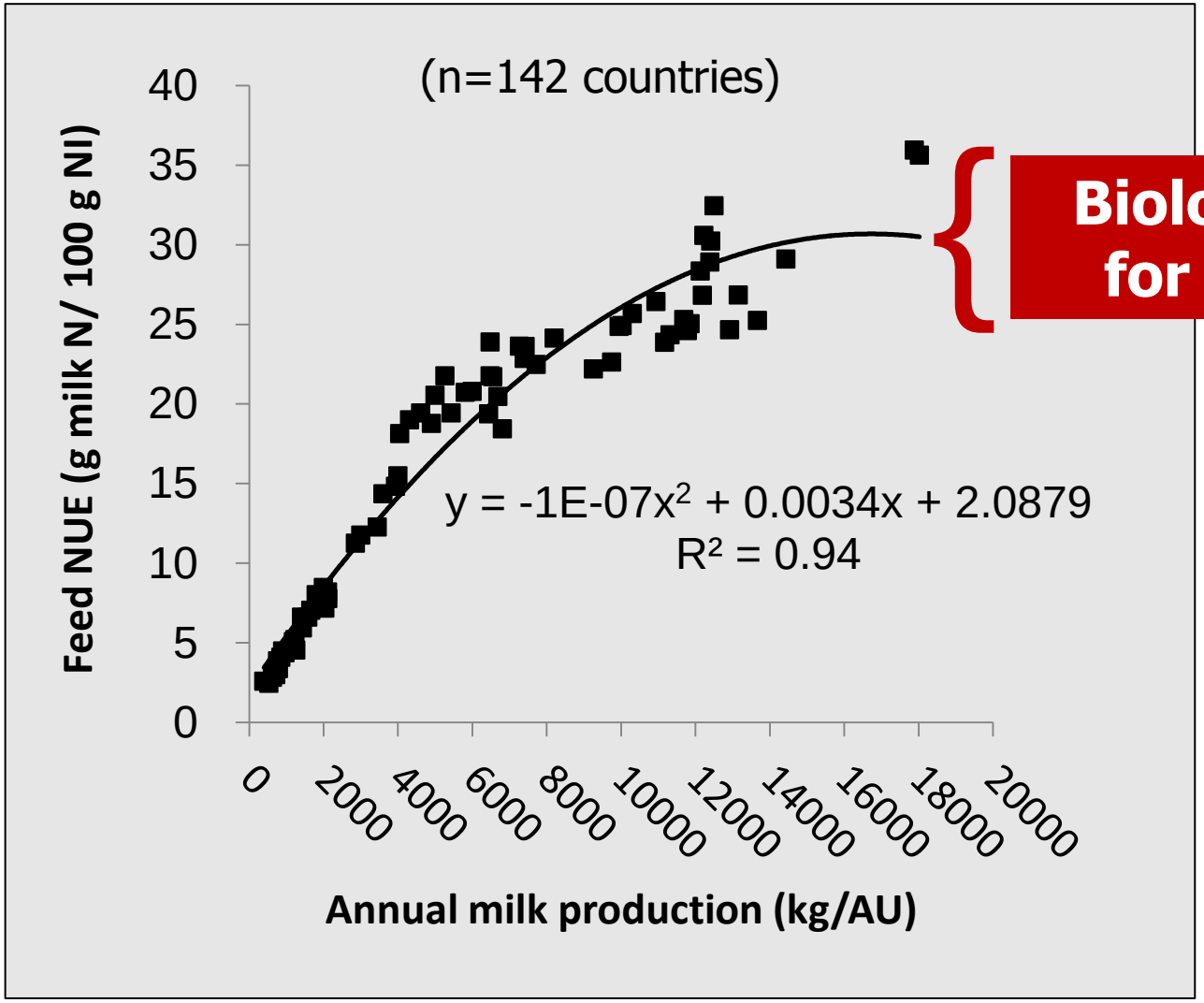
} What realistic improvements in NUE can be expected from dairy producers?

- Watershed
- Geographic (county, state, region, country)

Important components of NUE

1. Biological limits to incorporate N into products — **Fact of life** (not very manageable)
2. Fixed physical and operational farm features — **Somewhat manageable**
3. N applications to avoid risk — **Somewhat manageable**
4. Excessive N use (wastage) — **Manageable**

Feed N use efficiency in global dairy production systems



Biological limits for feed NUE?

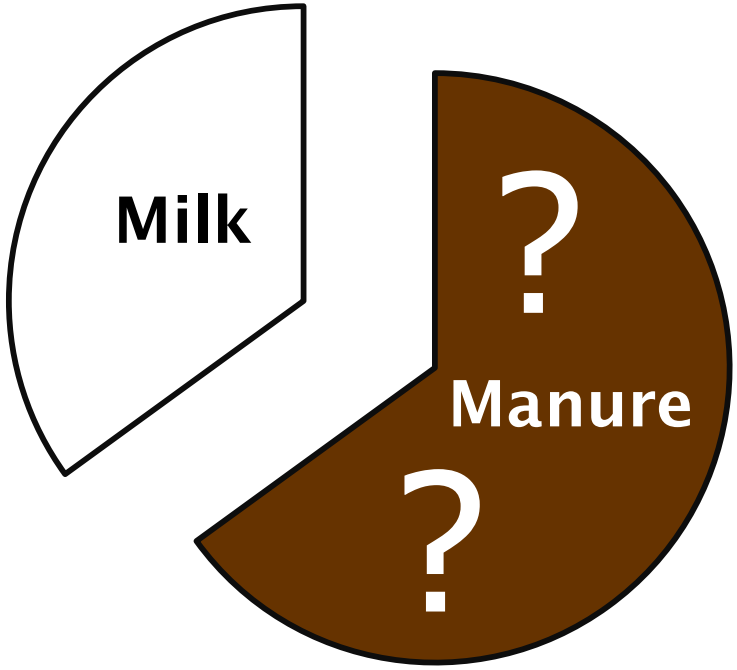
Powell et al., 2013

Typical range of feed N intake and feed NUE

Europe and 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

What happens to N excreted in manure?

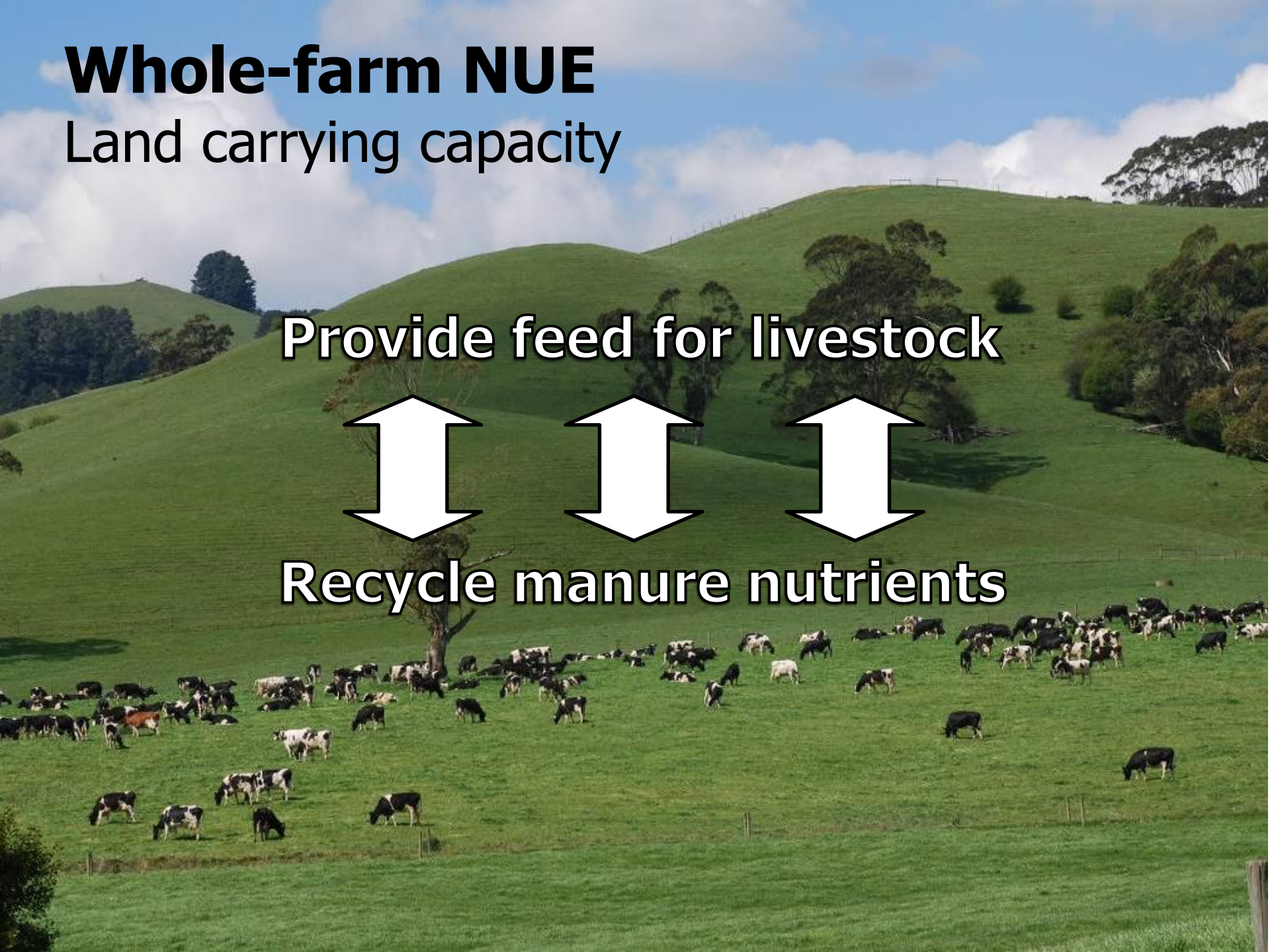


- Lost as ammonia **(20-40%)**
- Taken up by plants **(20-40%)**
- Lost via nitrate leaching **(10-20%)**
- Lost via denitrification **(3-5%)**
- Immobilized in soil **(not much)**

NUE
Dairy Production Systems

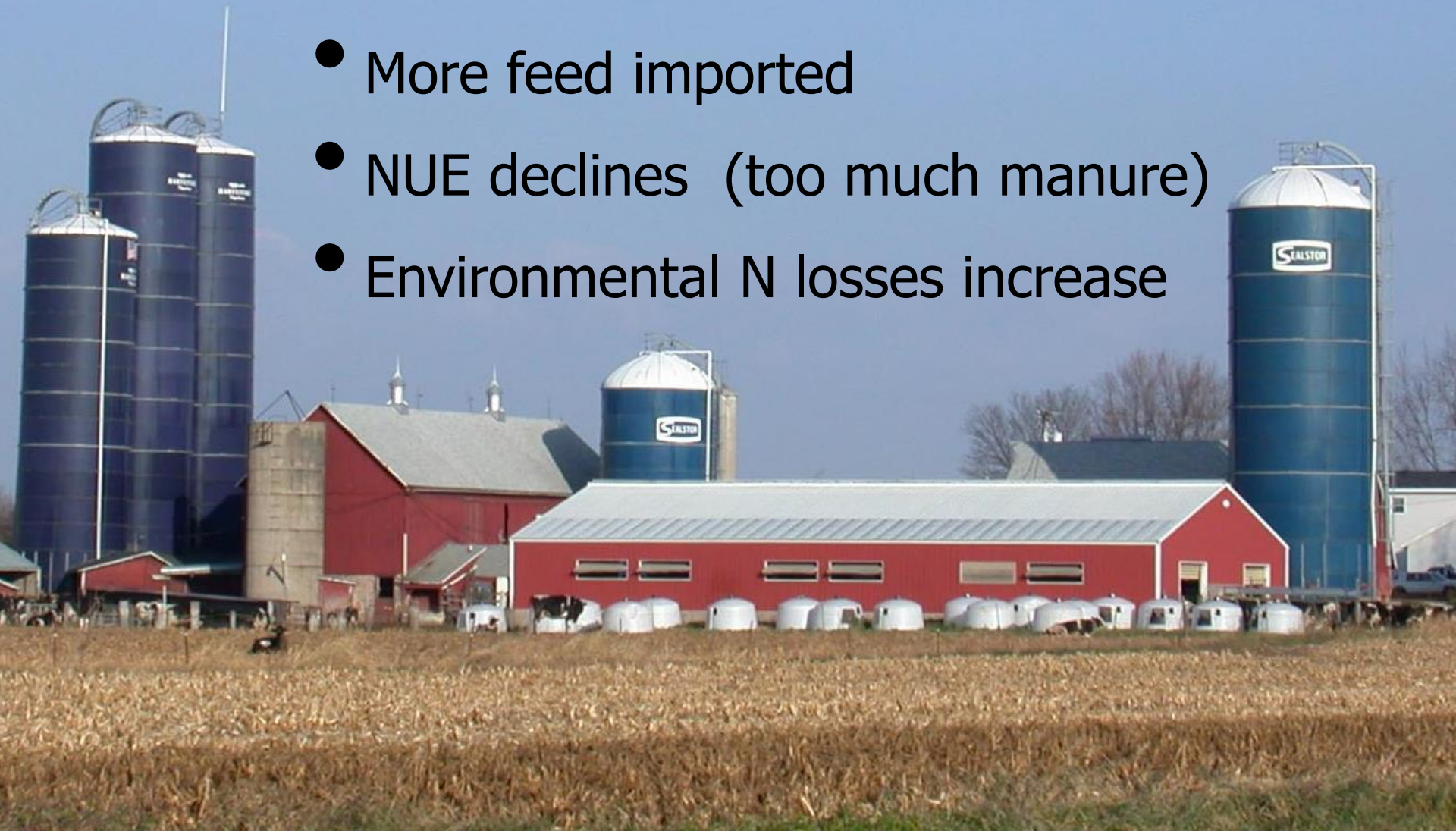
Whole-farm NUE

Land carrying capacity



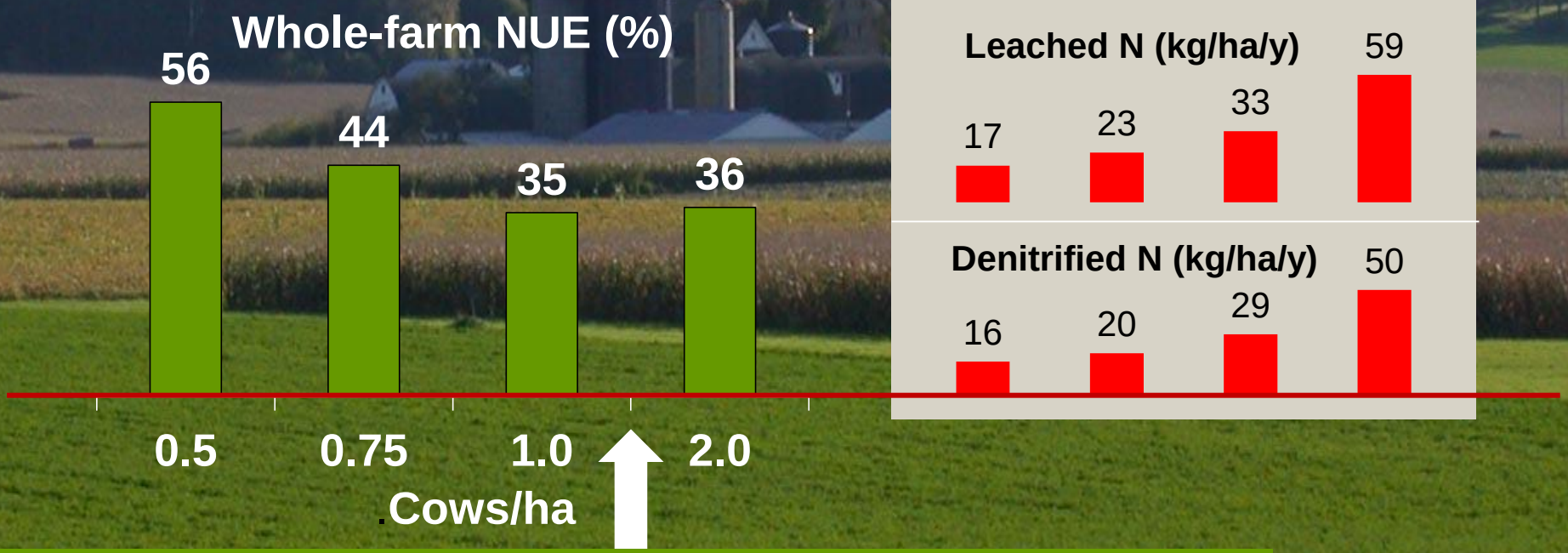
Whole-farm NUE

When carrying capacity is exceeded



- More feed imported
- NUE declines (too much manure)
- Environmental N losses increase

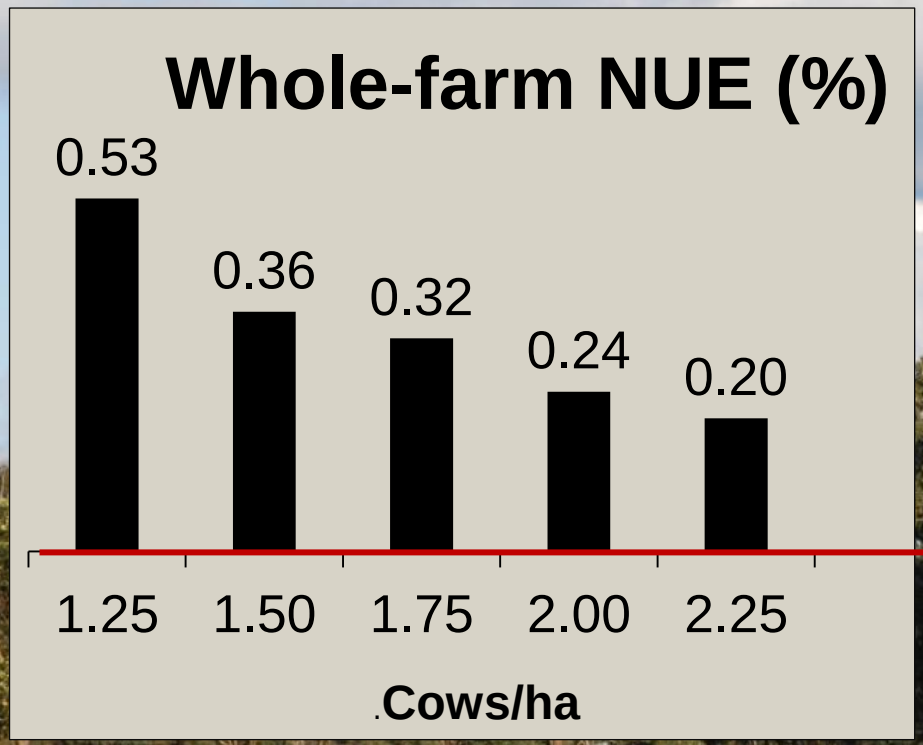
Too many cows ….too much manure

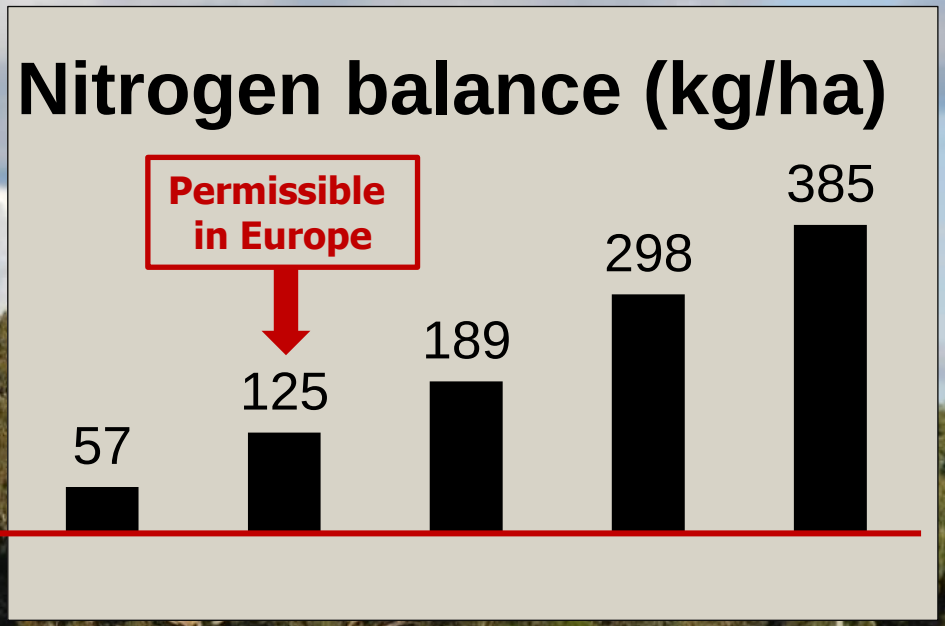


66% of Wisconsin dairy farms ≤ 1.5 cows/ha (≥1.6 acres/cow)
These farms are self sufficient in forage & grain

Powell et al., 2010

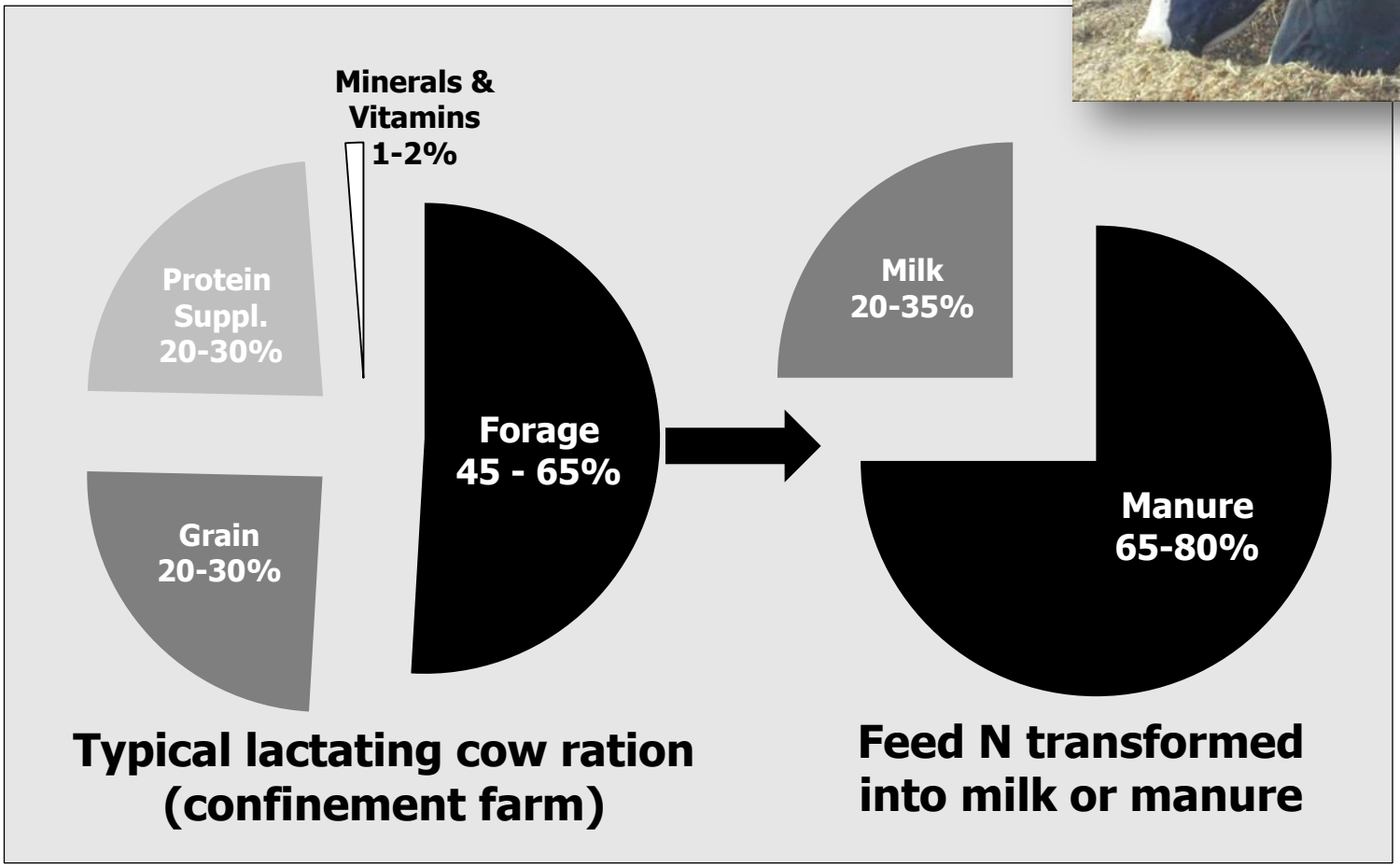
Pasture stocking rate impacts NUE and N balance



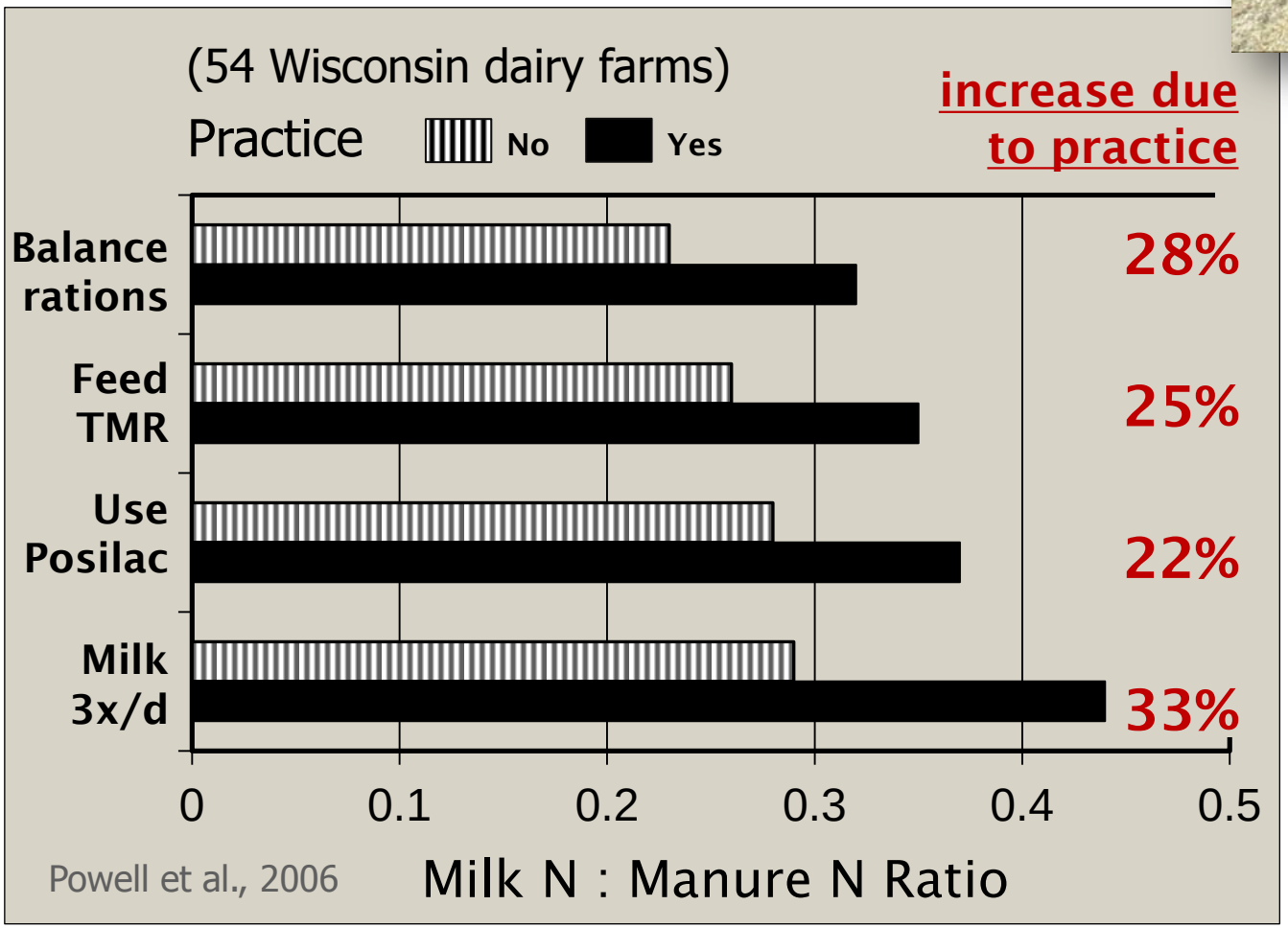


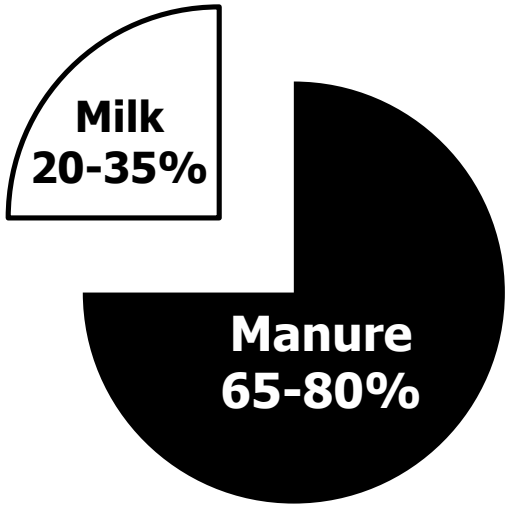
Staines et al., 2008

Rations and management impact feed NUE and N loss

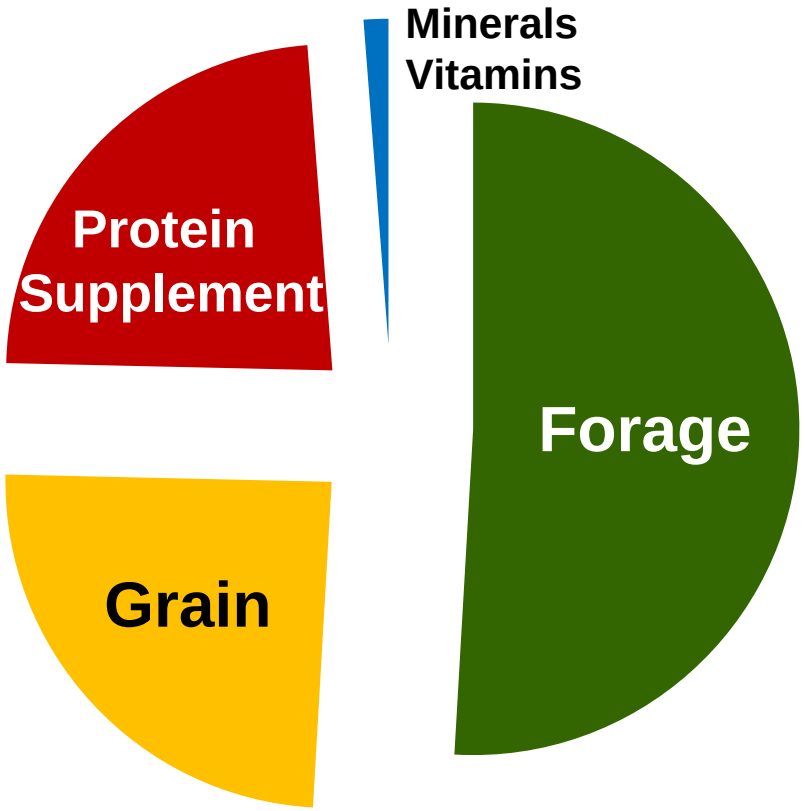


Management Impacts Milk N:Manure N Ratios





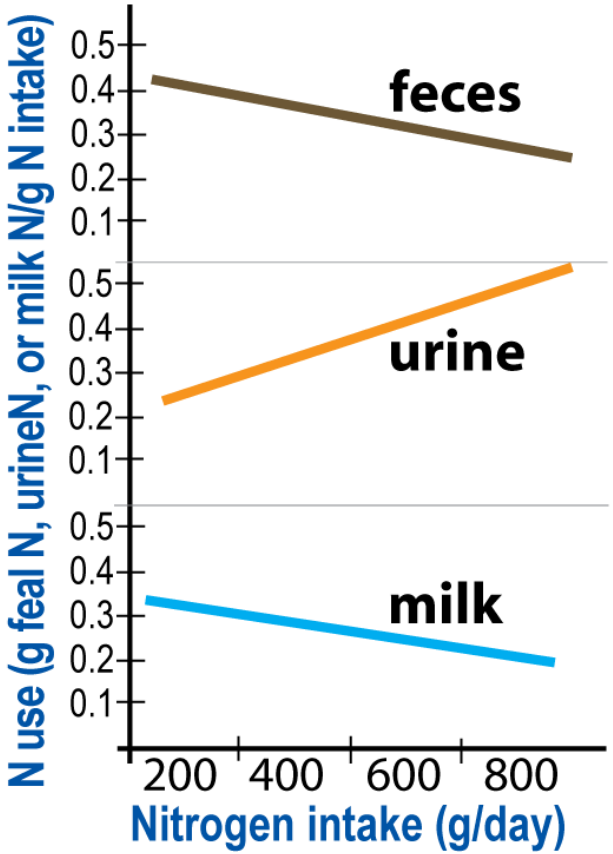
The rations we feed impact N use, manure chemistry, and N loss



Protein supplement's impact

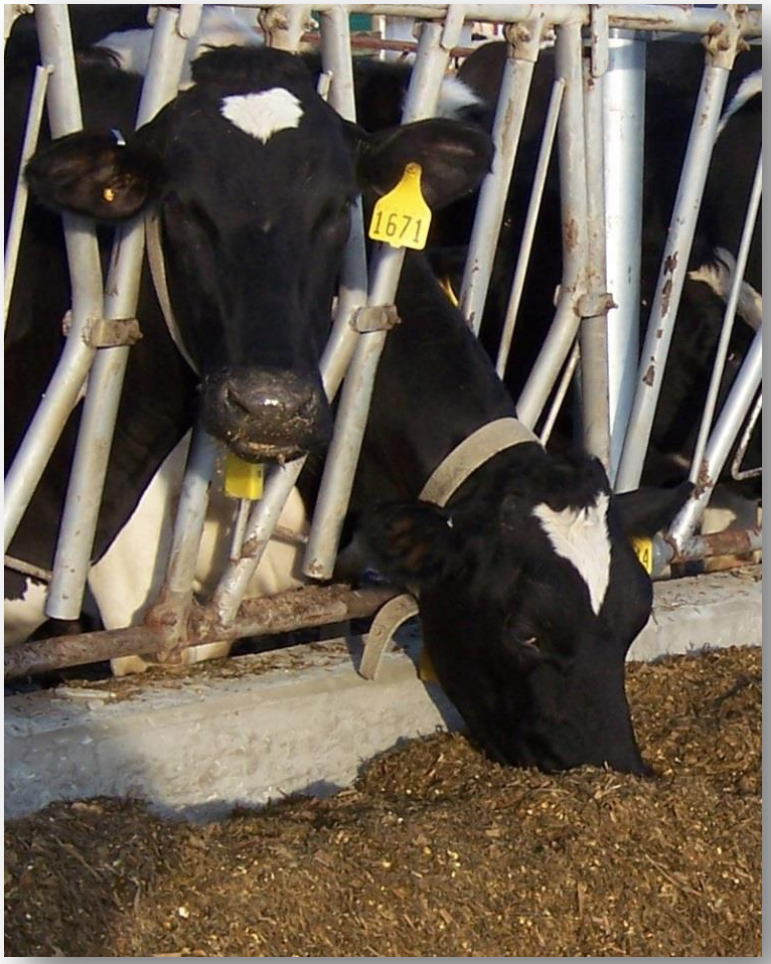
- Fecal N: Urinary N ratio
- Urea N in urine
- Ammonia emissions
- Nitrous oxide emissions
- Fecal N mineralization in soil
- Plant N uptake

As N intake exceeds requirement, feed NUE declines and urine N excretion increases



Castillo et al., 2000

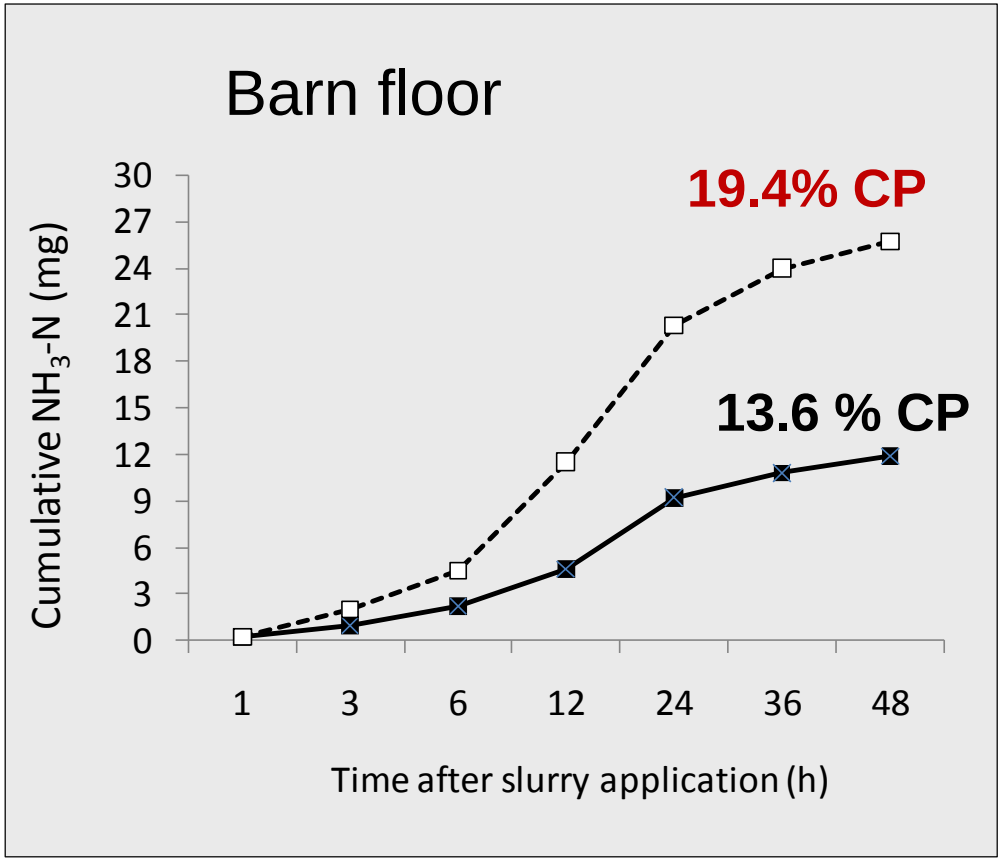
Excess dietary CP increases N in manure and urine

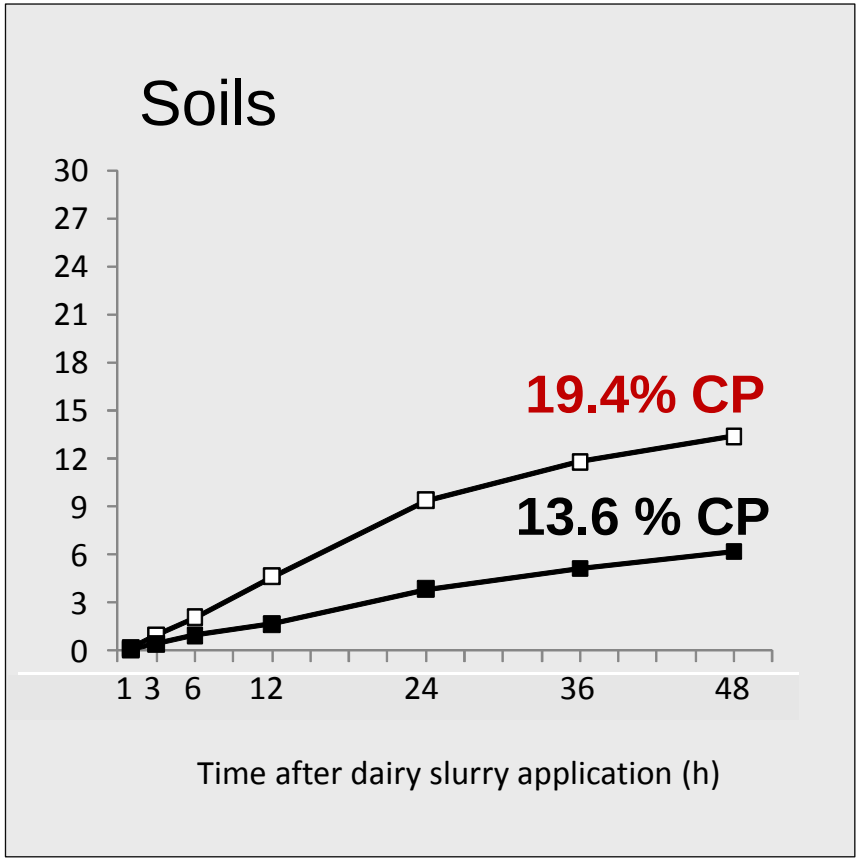


	13.6% CP	19.4% CP
Manure N g/cow/d	222	314
% Urine N	52	68
% Fecal N	48	32

Misselbrook et al., 2005

. . . and also ammonia emissions

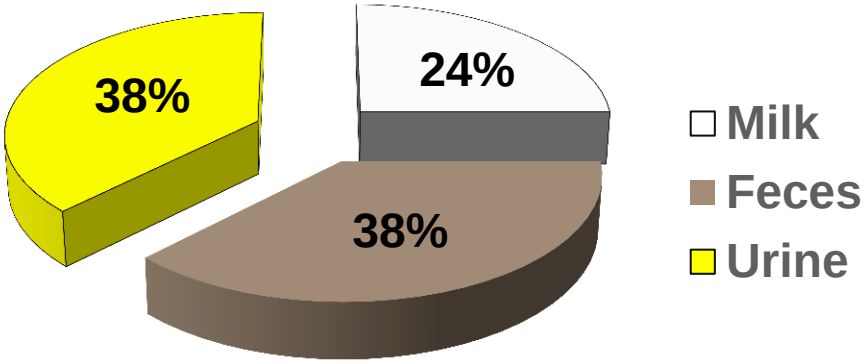




Misselbrook et al., 2005

Partitioning Feed N Intake

(typical confinement dairy farm)

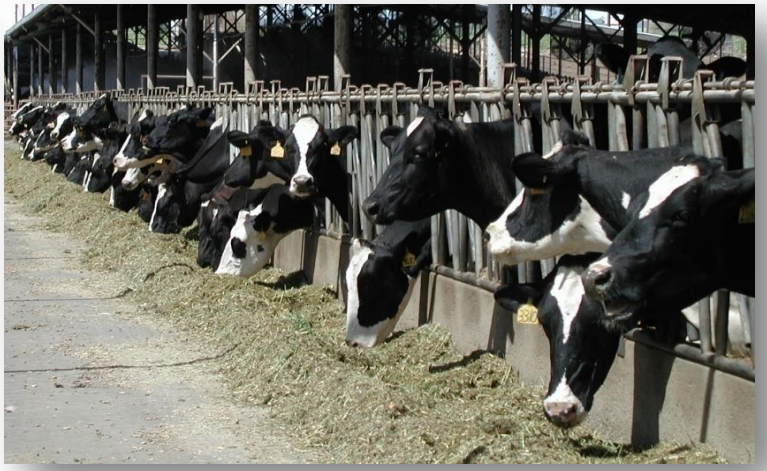


Urea in urine

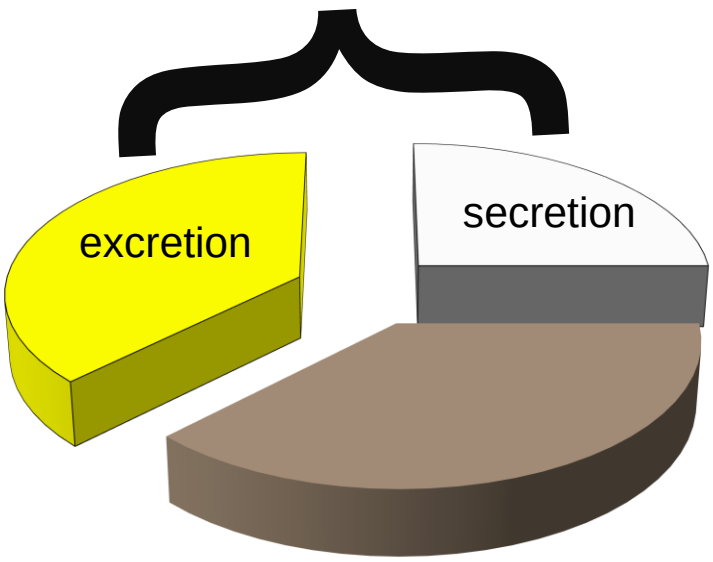
……greatest source of reactive N on dairy farms

How much feed N is consumed?

How much urea N is excreted?

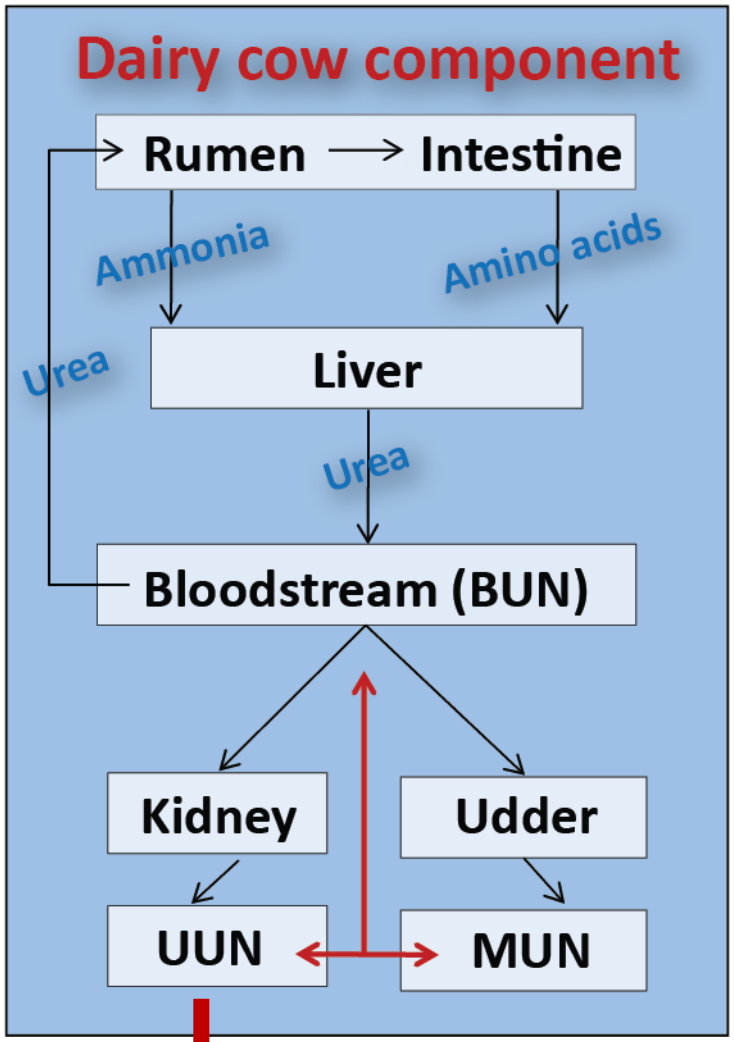


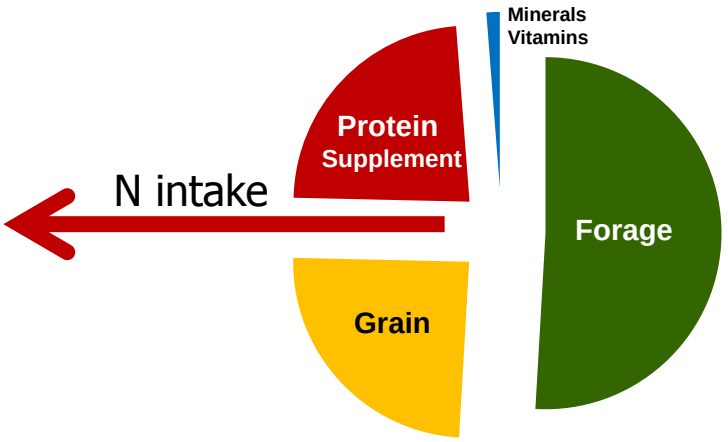
Analyze for
milk urea N (MUN)

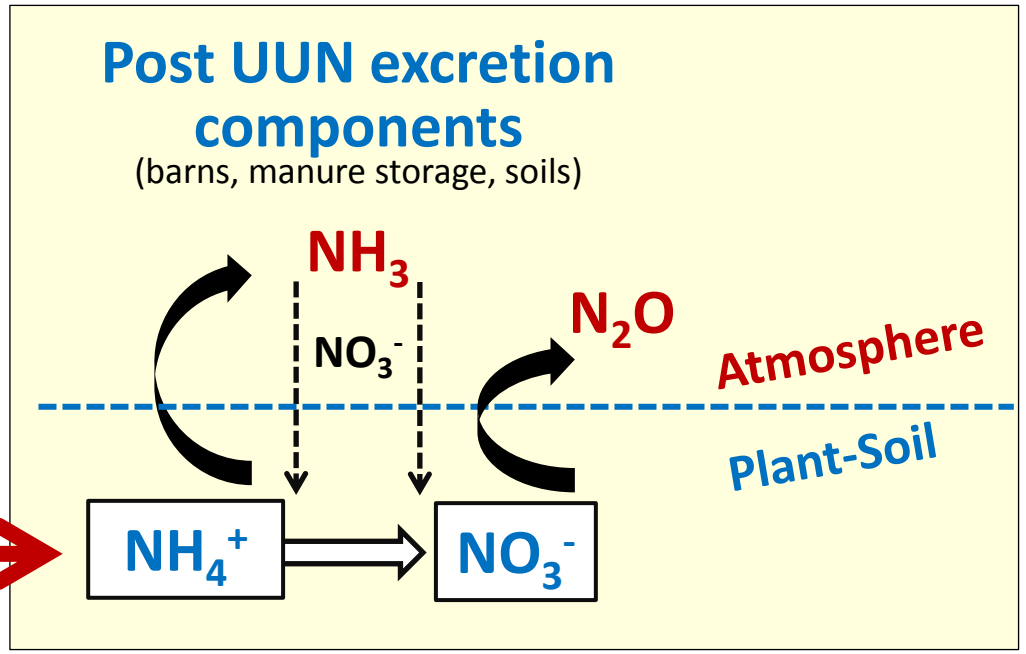


Milk
Feces
Urine

Urinary urea N: Greatest N_r source on dairy farms

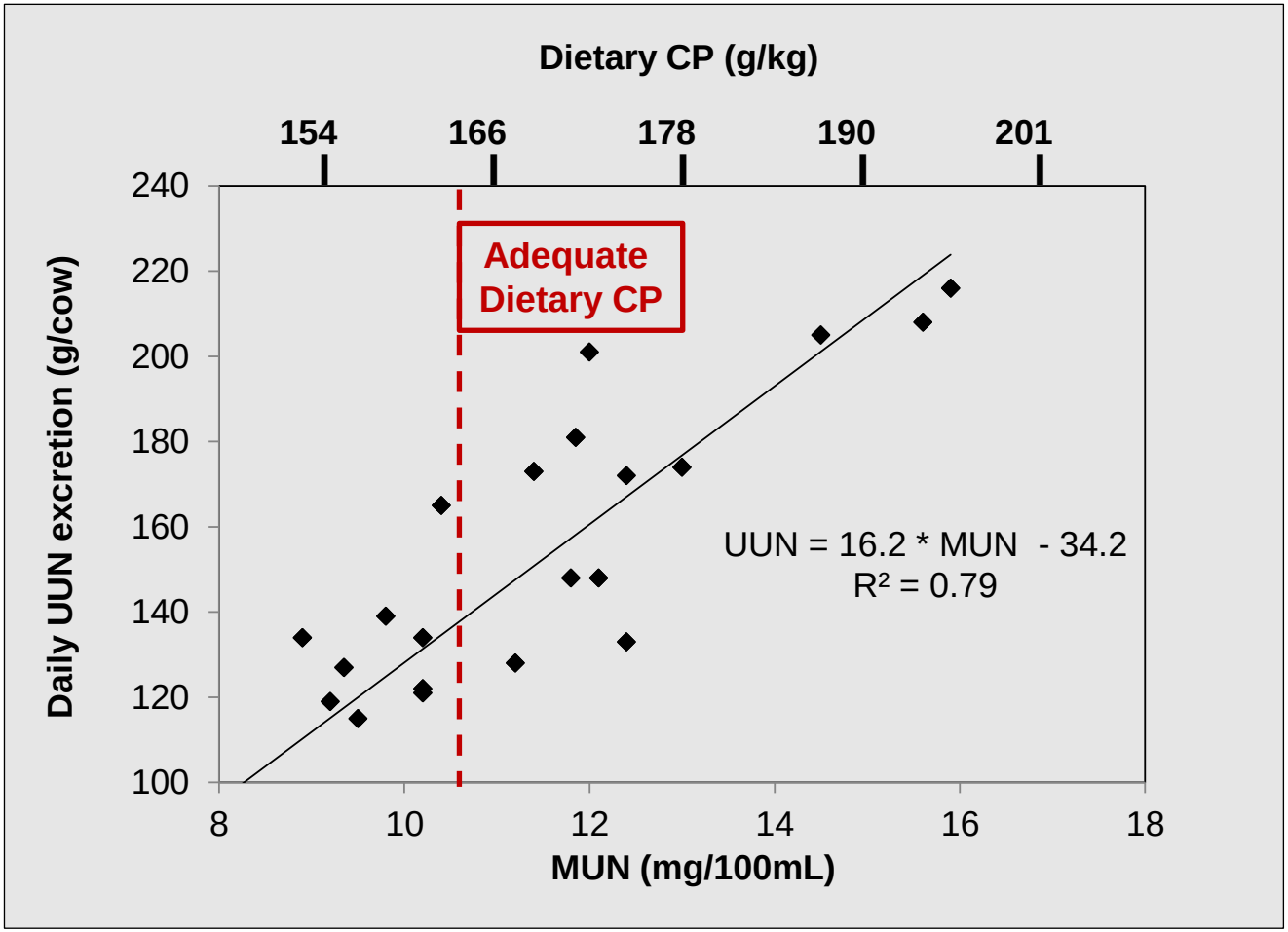






Powell et al., 2014

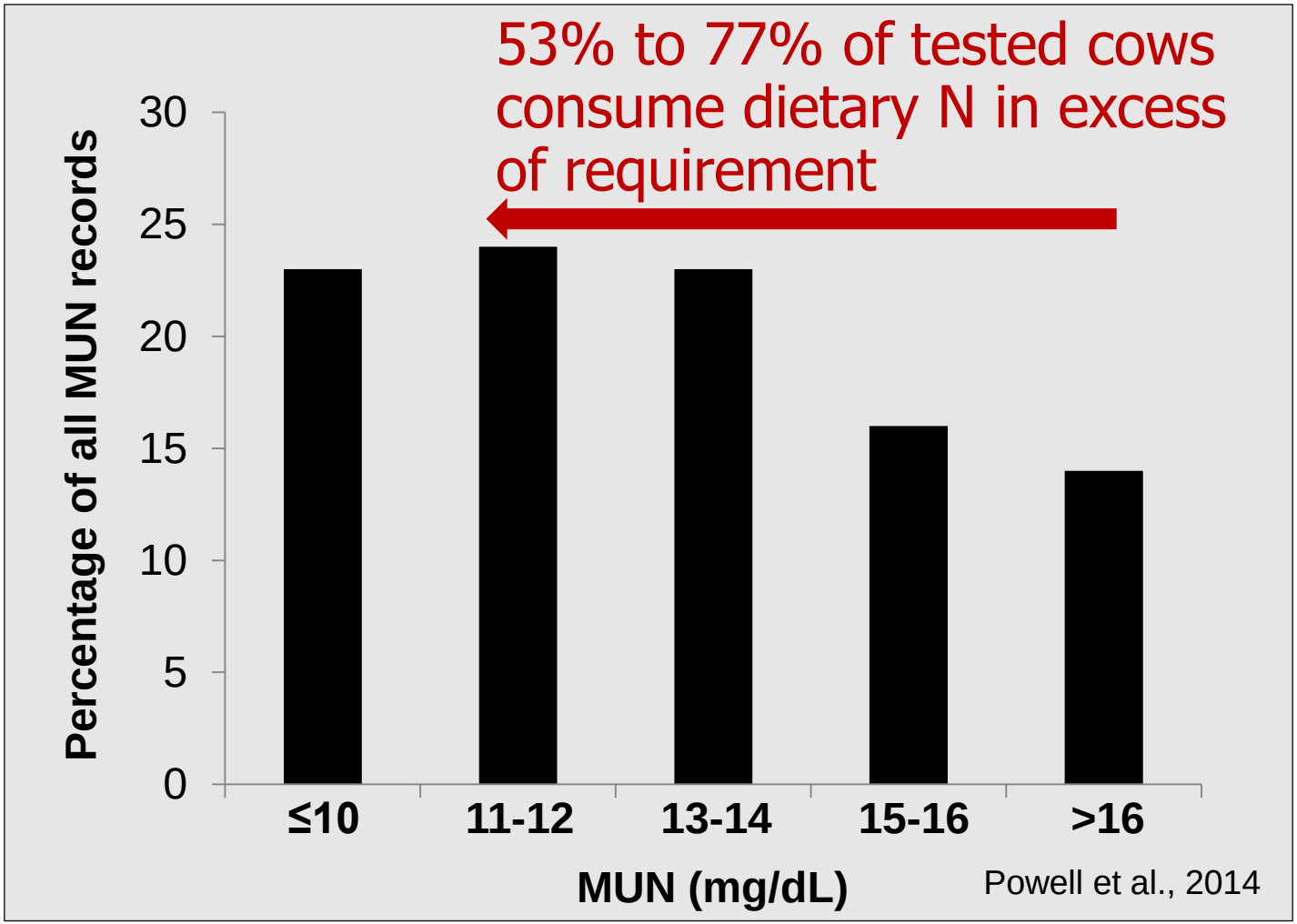
Relationships
Dietary CP, MUN and UUN



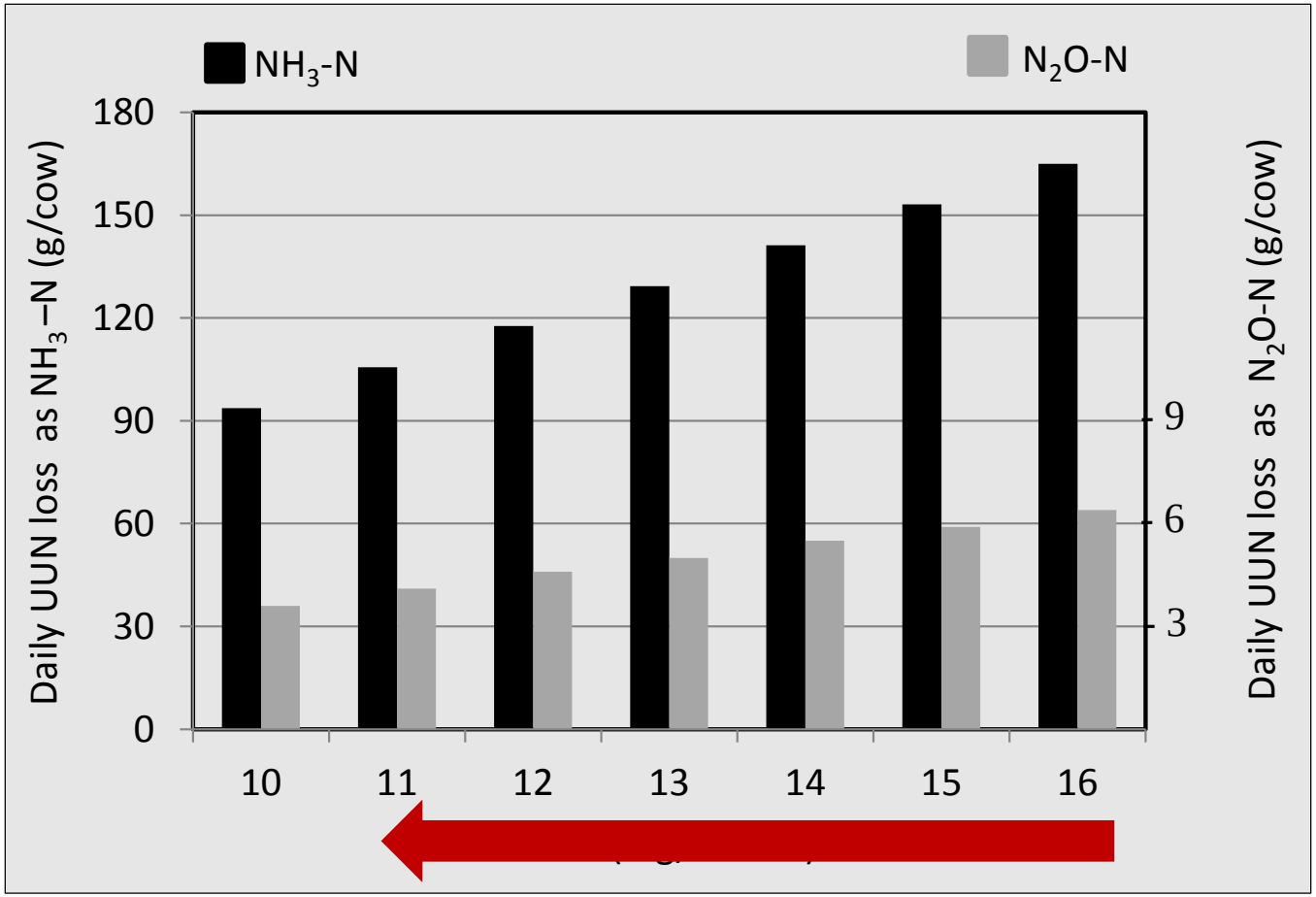
Wattiaux et al., 2011

Distribution of MUN Wisconsin dairy farms

(37,889 cows in 197 herds)



MUN, UUN and N emissions Wisconsin dairy farms



Feeding to achieve MUN of 12 to 10 mg/dL

Reduces { NH_3 emissions by 35 to 42%
N_2O emissions by 18 to 21%

Powell et al., 2014

Manure-NUE

Excreted N → **Crops/Pasture N**

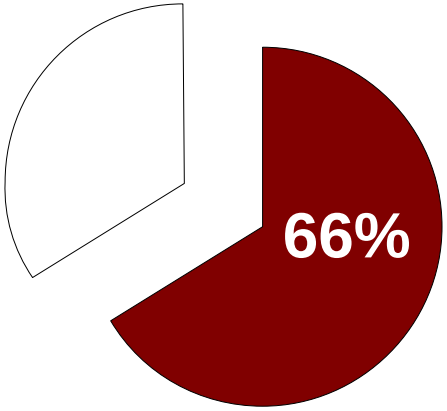
Collection
Storage
Land application
Manure N credits

→ **Manure NUE**
20-40%
(of excreted N)

Manure collection

(n=54 Wisconsin dairy farms)

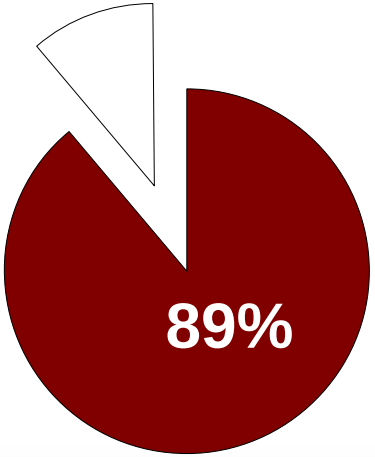
Tie-stall barns



Collected

Not Collected

Free-stall barns



Powell et al., 2005

Uncollected manure on Wisconsin dairy farms

- Manure N deposition 340 to 5470 kg/ha/y
- Some farmers rotate outside areas with pasture and/or crops

Powell et al., 2005

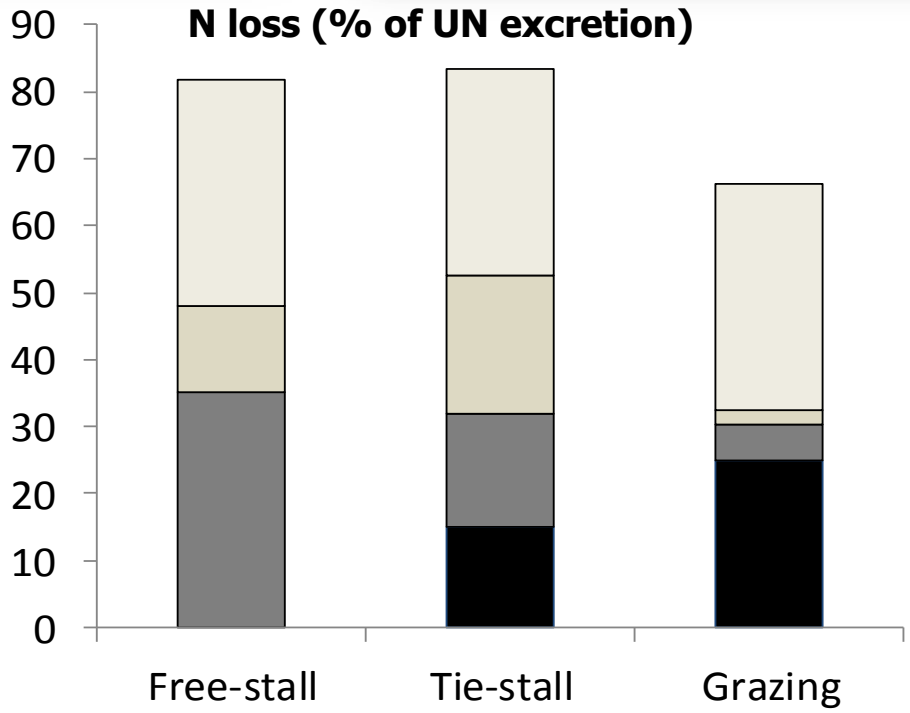
A farm's operational features impact N loss

Pool 1
Excreted in non-productive areas

Pool 2
During collection and storage

Pool 3
During land application

Pool 4
After land application

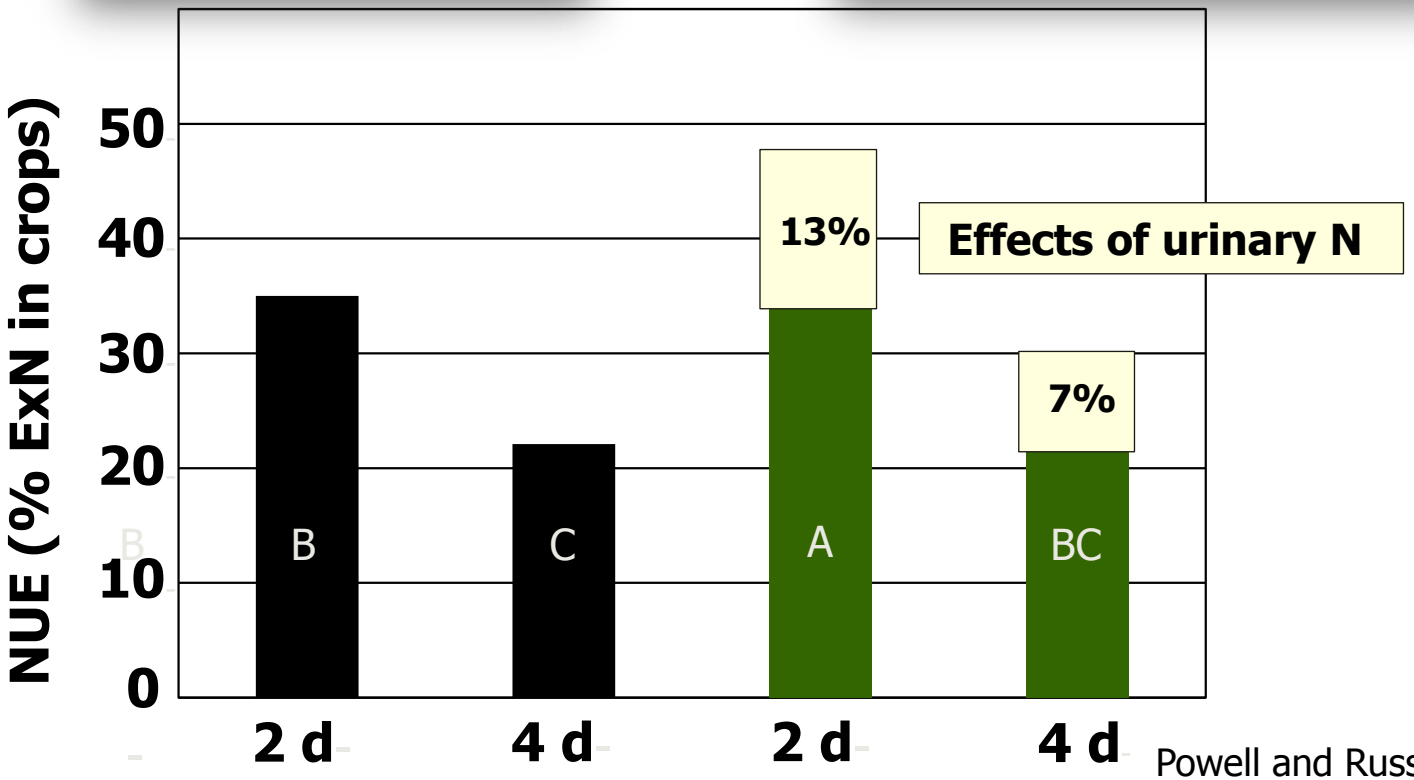


Nitrogen use efficiency

Barn manure

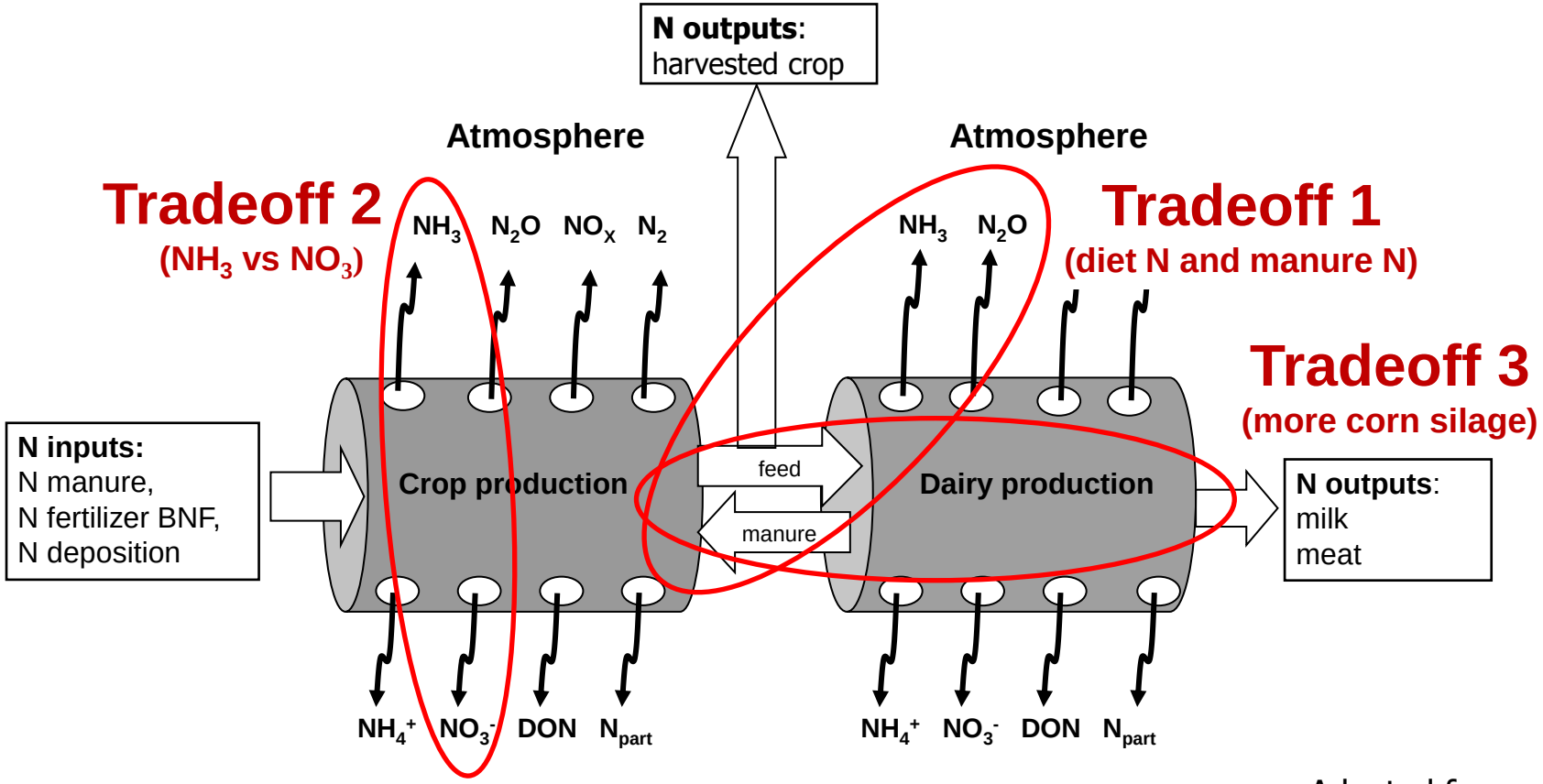
4-year study in WI

Outside manure



Powell and Russelle, 2008

2. Tradeoffs in N use and loss

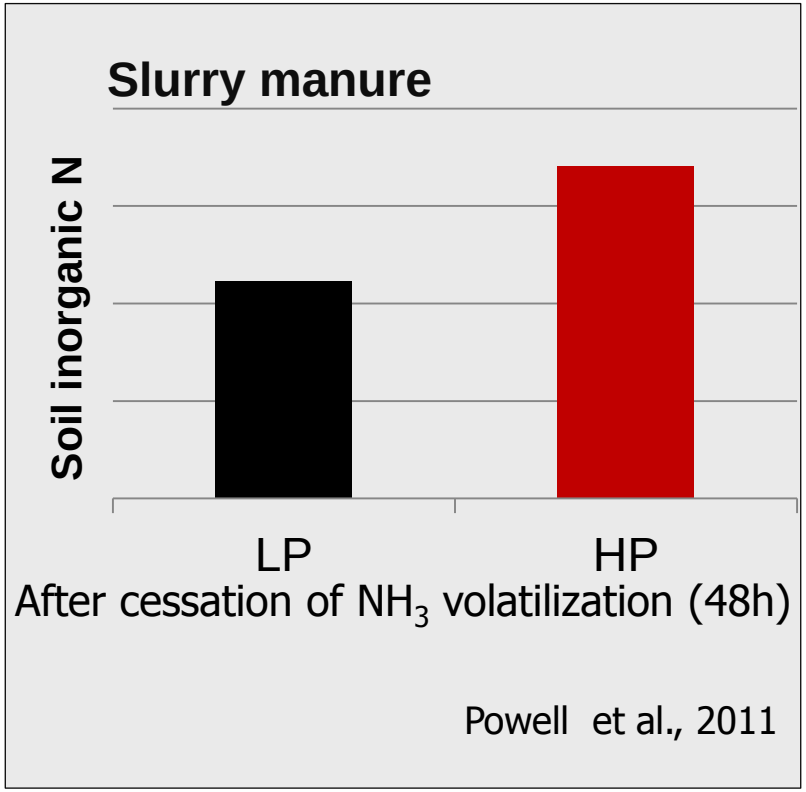


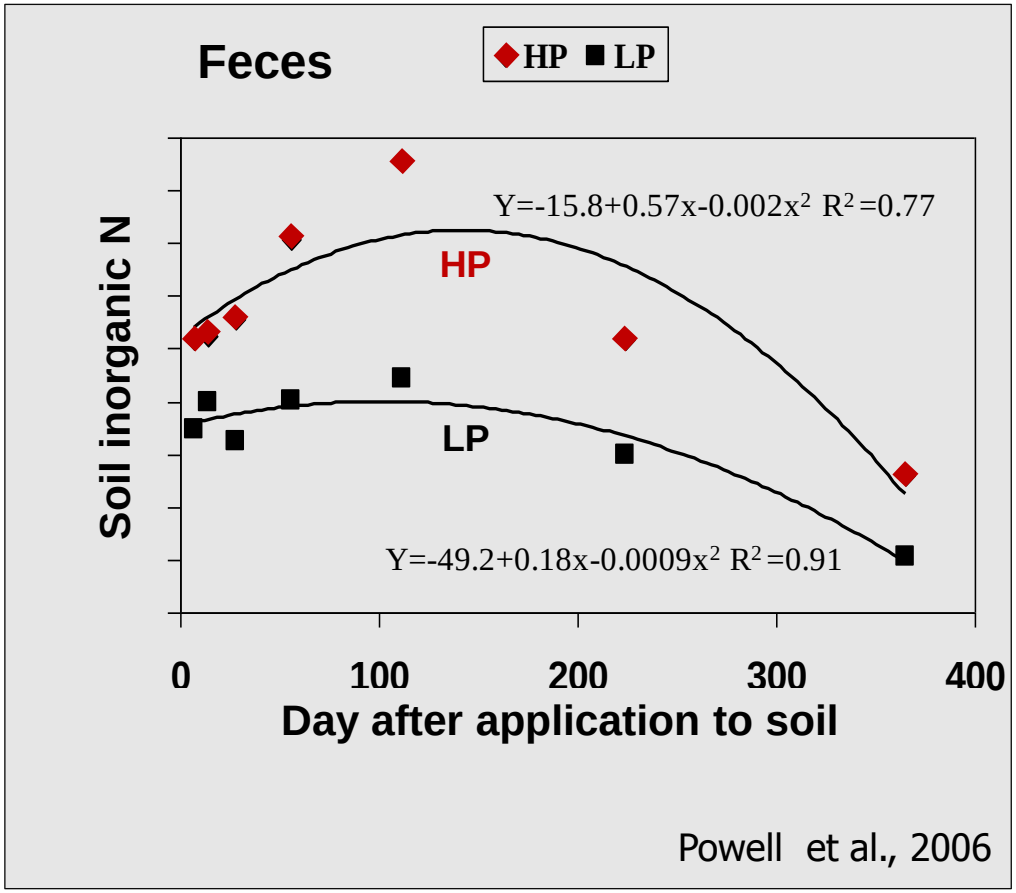
Adapted from Oenema et al., 2009

TRADEOFF 1

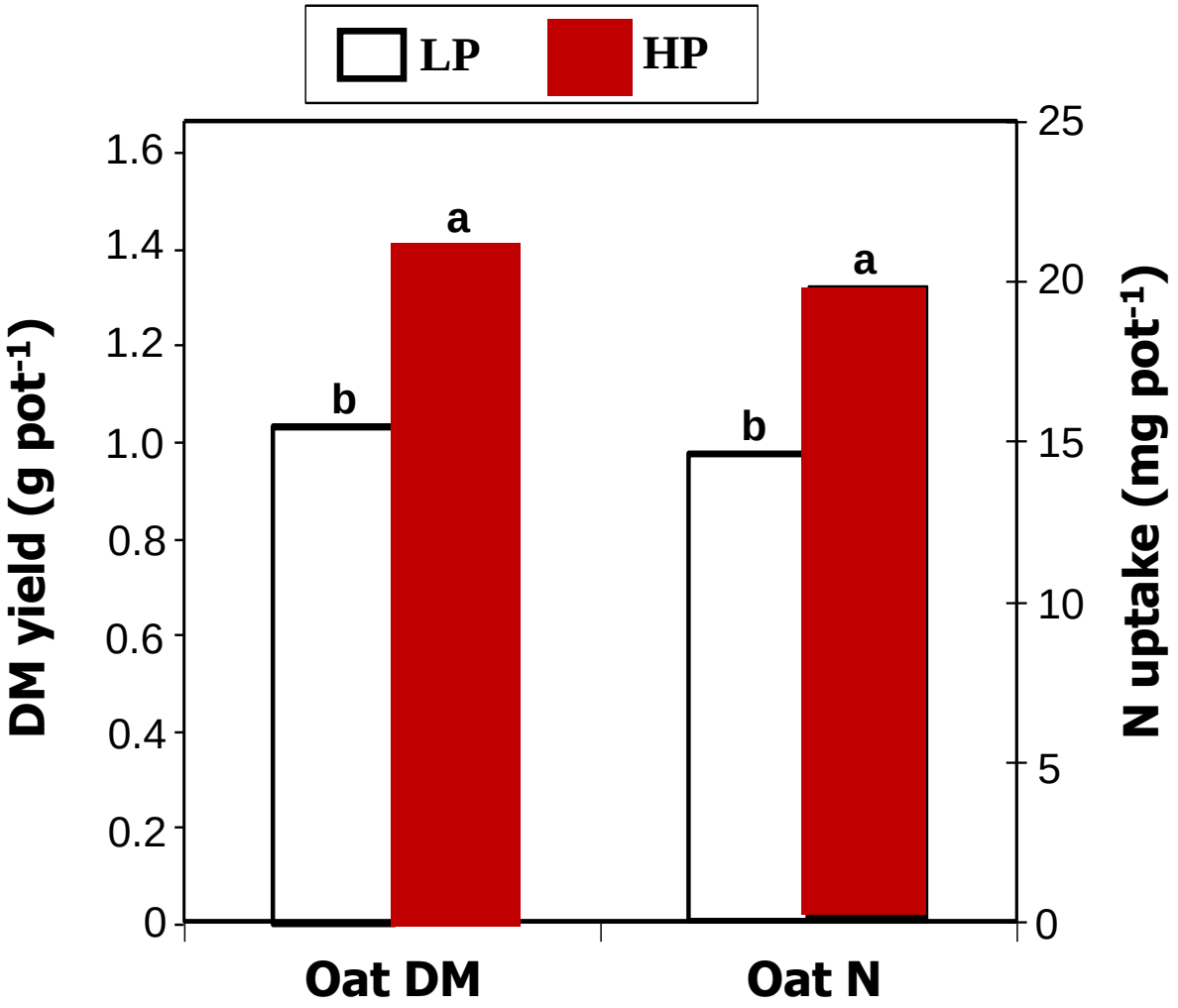
Level of CP in dairy cow rations impacts UN excretion and NH_3 loss

.....but also manure N availability to plants





. . . crop yield and N uptake

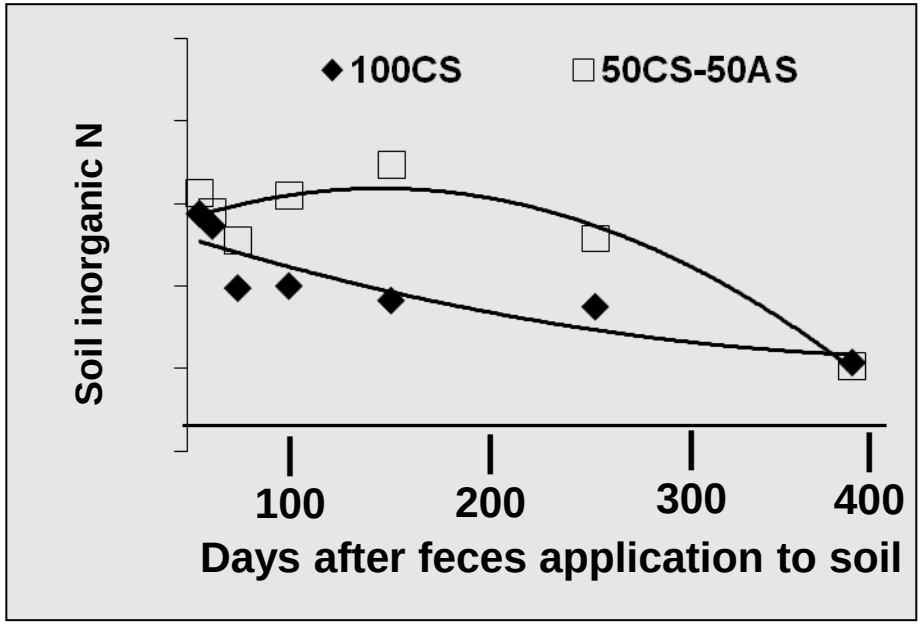


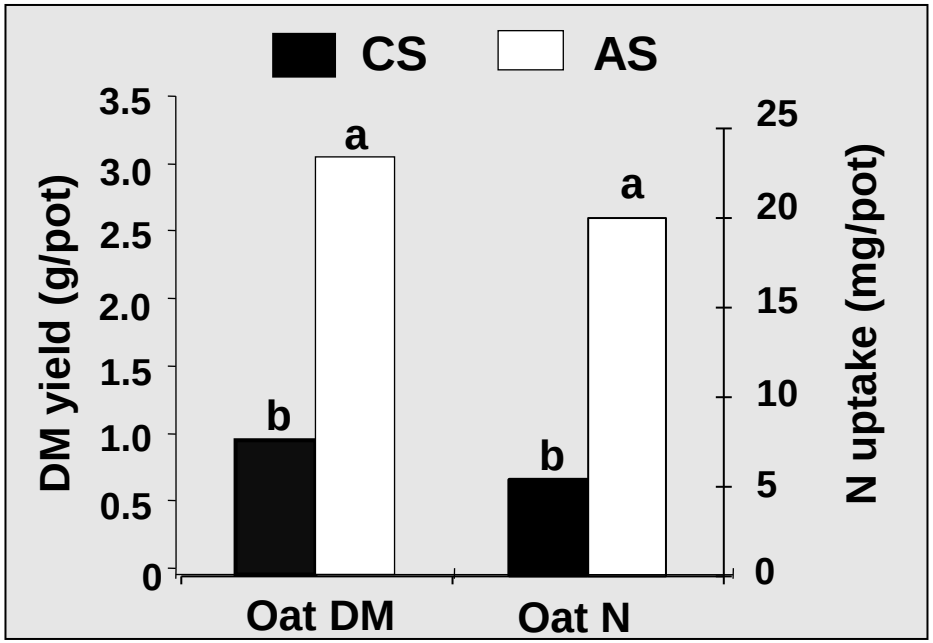
Powell et al., 2006

TRADEOFF 2

More corn silage may feed more cows

. . . but may reduce manure N availability to corn



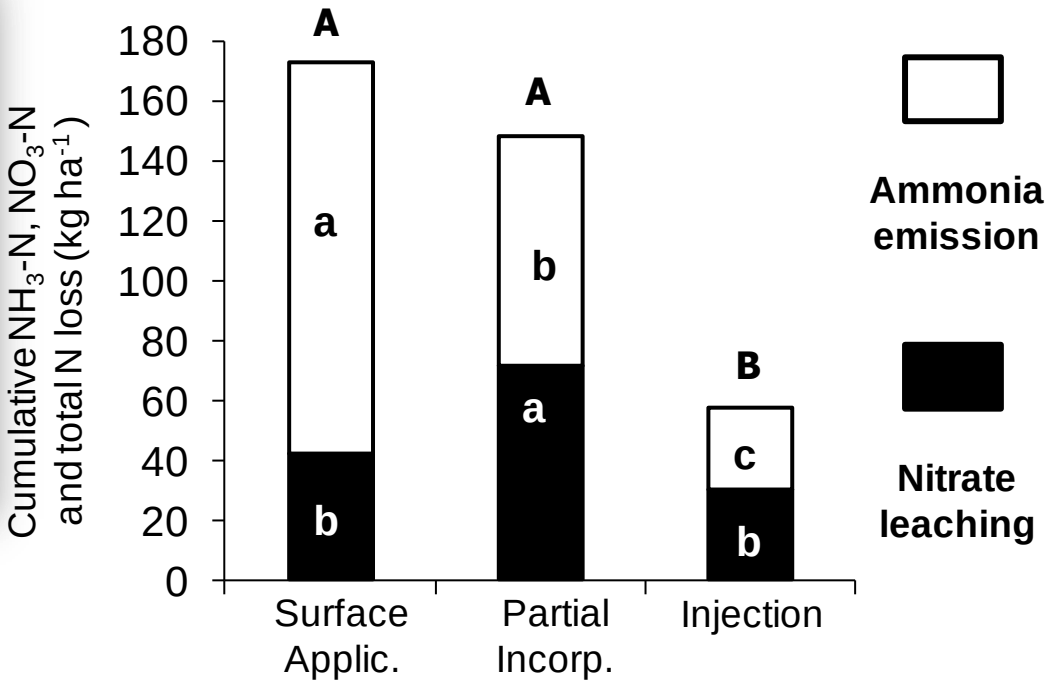


Powell et al., 2006

TRADEOFF 3

Tillage may reduce NH_3 emission .....but may increase NO_3 leaching

4-y field trial with corn Wisconsin (Powell et al., 2010)



% loss of total manure N applied	26.8	22.2	9.6
% as ammonia	20.0	10.9	4.9
% as nitrate	6.8	11.3	4.7

Summary

Improvements in NUE on dairy farms through management of livestock and their excreta

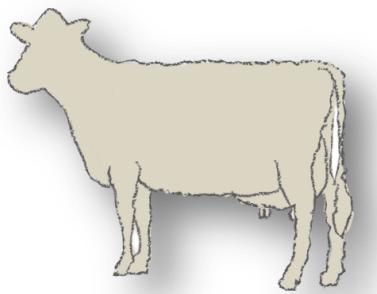
- Maintain good stocking rates
- Feed most balanced rations possible
- Collect manure and conserve urine
- Recognize and incorporate N use and N loss tradeoffs into N management planning

Impediments to enhanced NUE on dairy farms

Recognize factors that impact NUE

- Biological (N incorporation into products)
- Physical (climate, soils)
- Farm 'fixed' operational features (e.g., barns, manure storage)
- Excessive use (risk avoidance, wastage)

What realistic improvements in NUE can be expected from producers?



- Establish N use baselines (using MUN, NUE, N balance) for monitoring progress towards desired change.
- What NUE targets are actually achievable?
- Manage N losses?

Congratulations!

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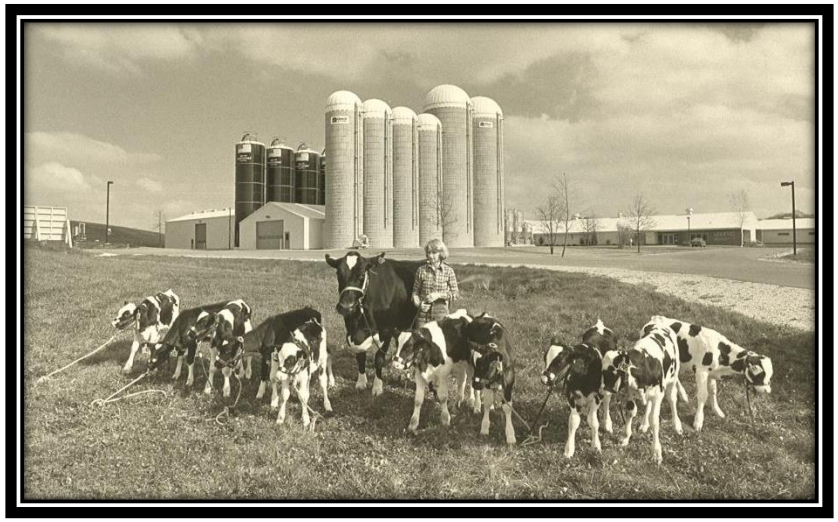

Prairie du Sac

Marshfield