Research Associate

Department of Dairy Science

UW Madison

(2000-2003)

04/09/03

Estimating nitrogen loss from dairy cow manure

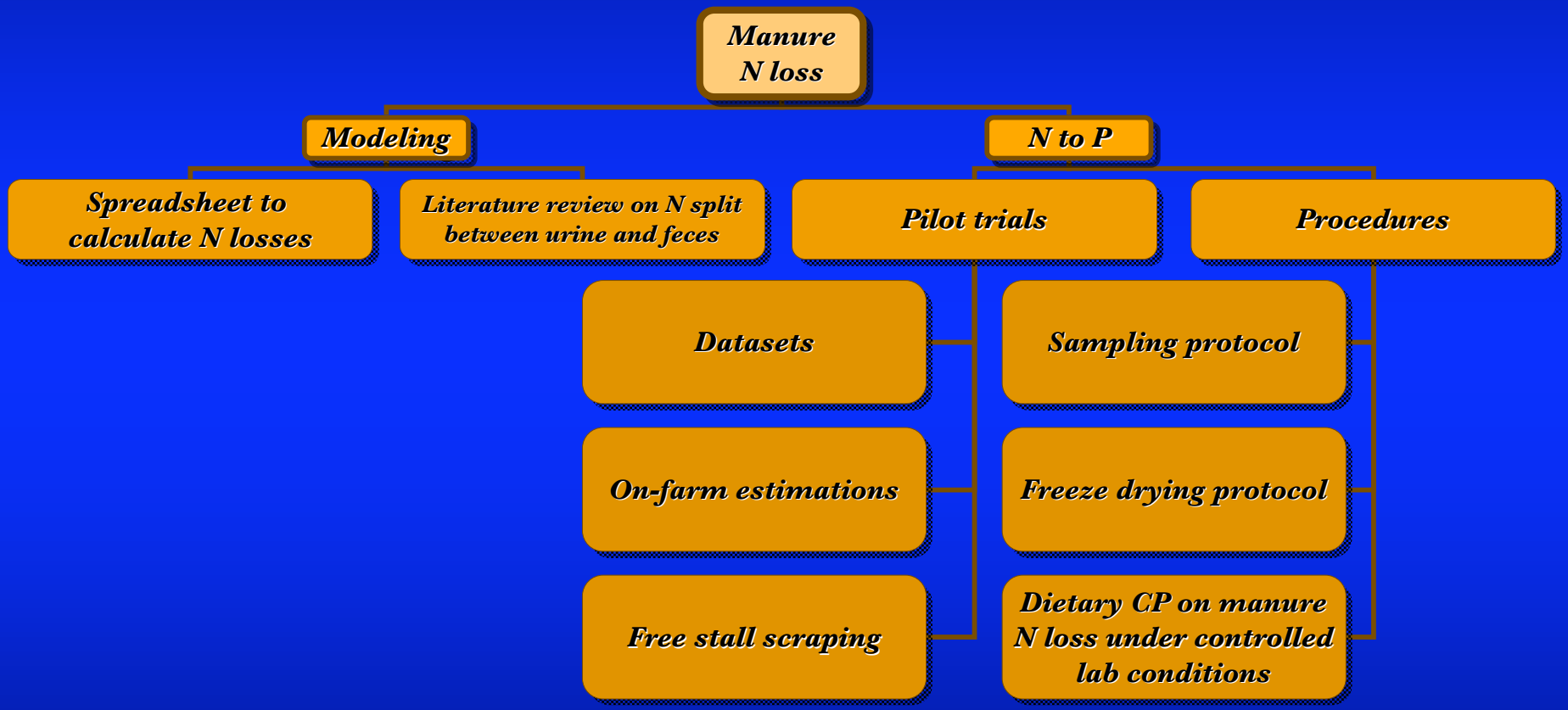
Vinicius R. Moreira

and Larry D. Satter

Department of Dairy Science / UW-Madison
USDA-ARS DFRC

04/09/03

Synopsis of activities



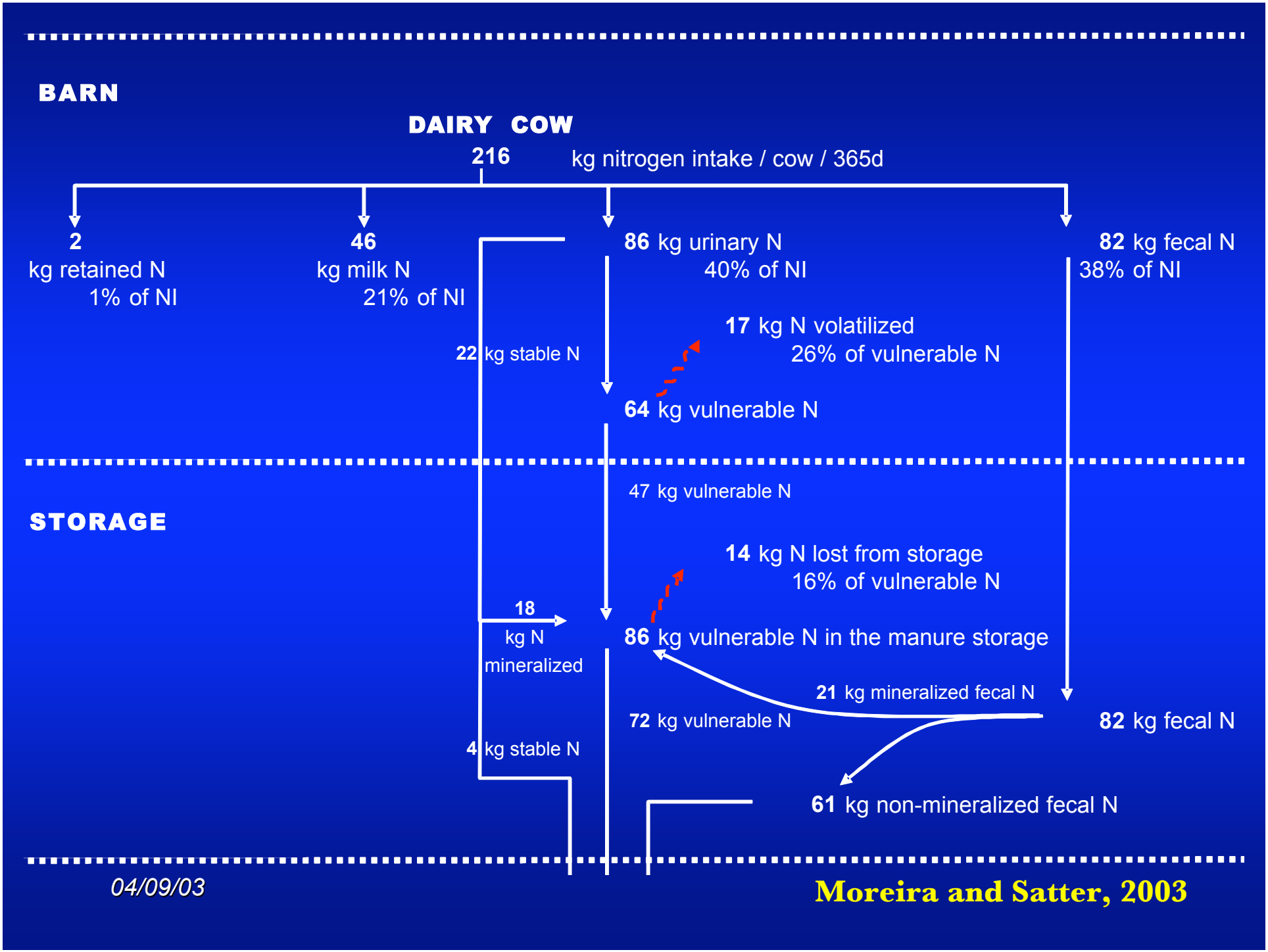
Modeling N losses

- **Assumptions for the dairy cow:**
  - 13-month calving interval: 310d lactation + 55d dry in a year, producing one calf;
  - Primiparous accounted for ~1/3 of the herd (some N retention);
  - Rolling-herd average: 9100kg milk with 3.2%CP;
  - Dry matter intake: 23.2kg/d while lactating and 12.5kg/d for the dry period;
  - Dietary CP: 17.5% and 13.5% for lactating and dry period diets, respectively

Conventions

N retained

N lost


BARN
DAIRY COW
216 kg nitrogen intake / cow / 365d
2 kg retained N 1% of NI
46 kg milk N 21% of NI
86 kg urinary N 40% of NI
82 kg fecal N 38% of NI
17 kg N volatilized 26% of vulnerable N
22 kg stable N
64 kg vulnerable N
47 kg vulnerable N
STORAGE
14 kg N lost from storage 16% of vulnerable N
18 kg N mineralized
86 kg vulnerable N in the manure storage
21 kg mineralized fecal N
72 kg vulnerable N
82 kg fecal N
4 kg stable N
61 kg non-mineralized fecal N
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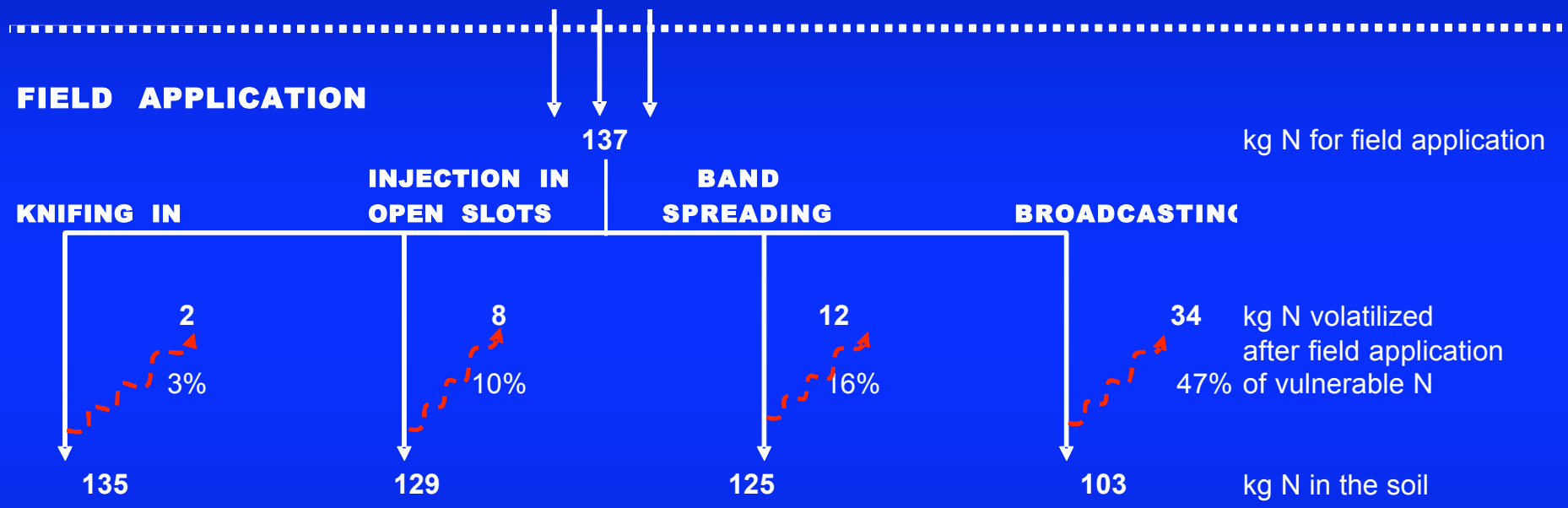
Moreira and Satter, 2003



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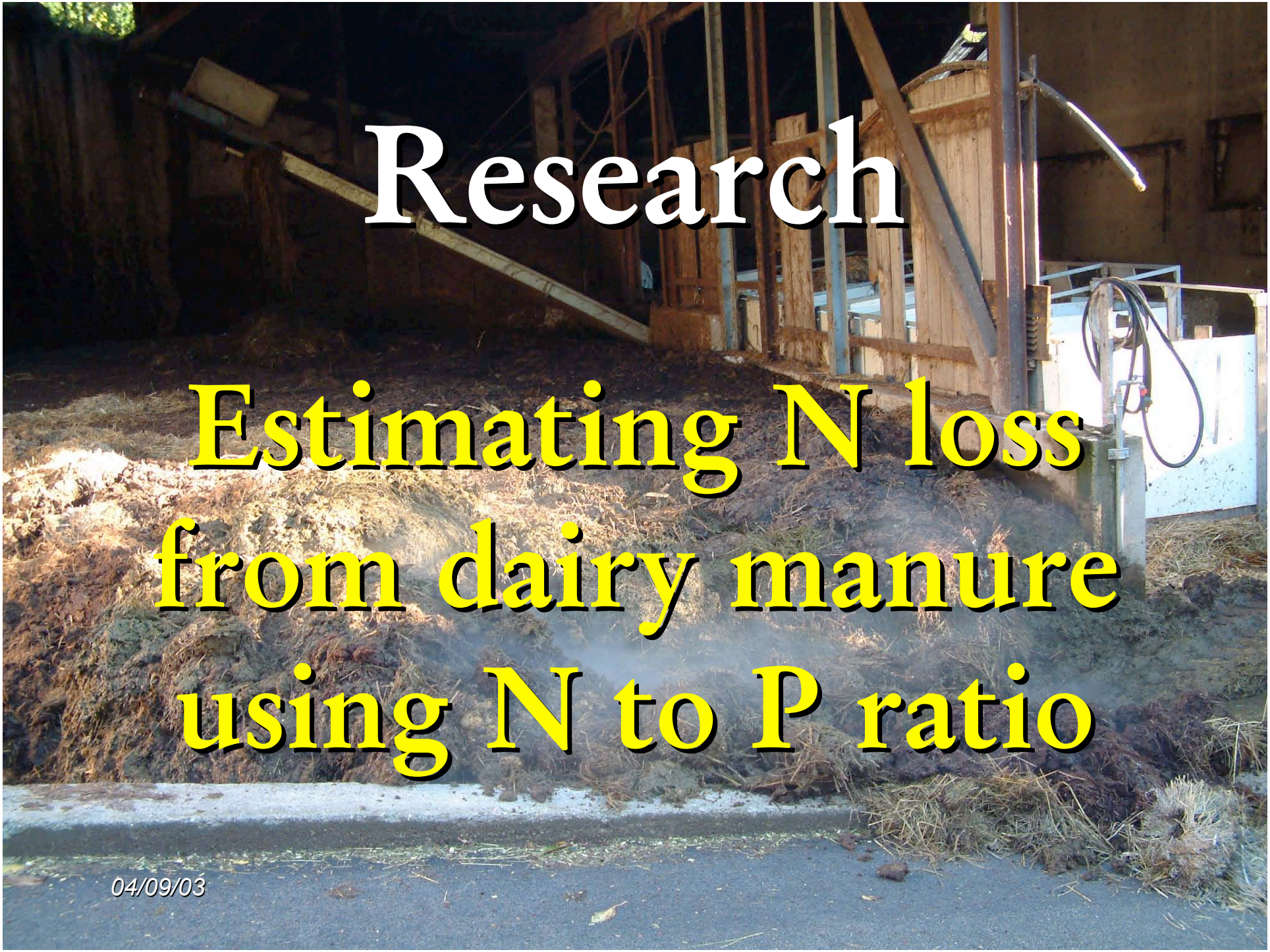
Moreira and Satter, 2003



Research

Estimating N loss from dairy manure using N to P ratio

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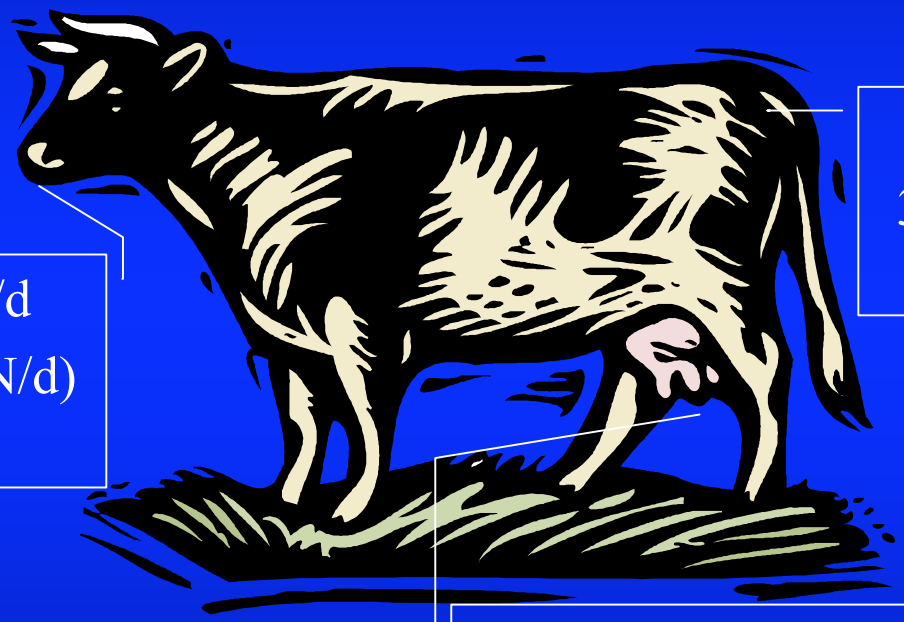
General objective

- To evaluate the impact of dairy manure management on N loss from the moment of excretion until the manure storage facility is emptied, using N to P ratio.

N and P flow thru a lactating dairy cow



By difference:
336gN & 47gP
N/P = 7.15

DMI = 17.6kg/d
16.8%CP (473gN/d)
0.42%P (72gP/d)

Milk = 27.8kg/d
3.13%CP (137gN/d)
0.09%P (25gP/d)

Sources for N and P loss from dairy production systems

↑N

↑N

↓N & P

↑N

↑N

↑N

↓N & P

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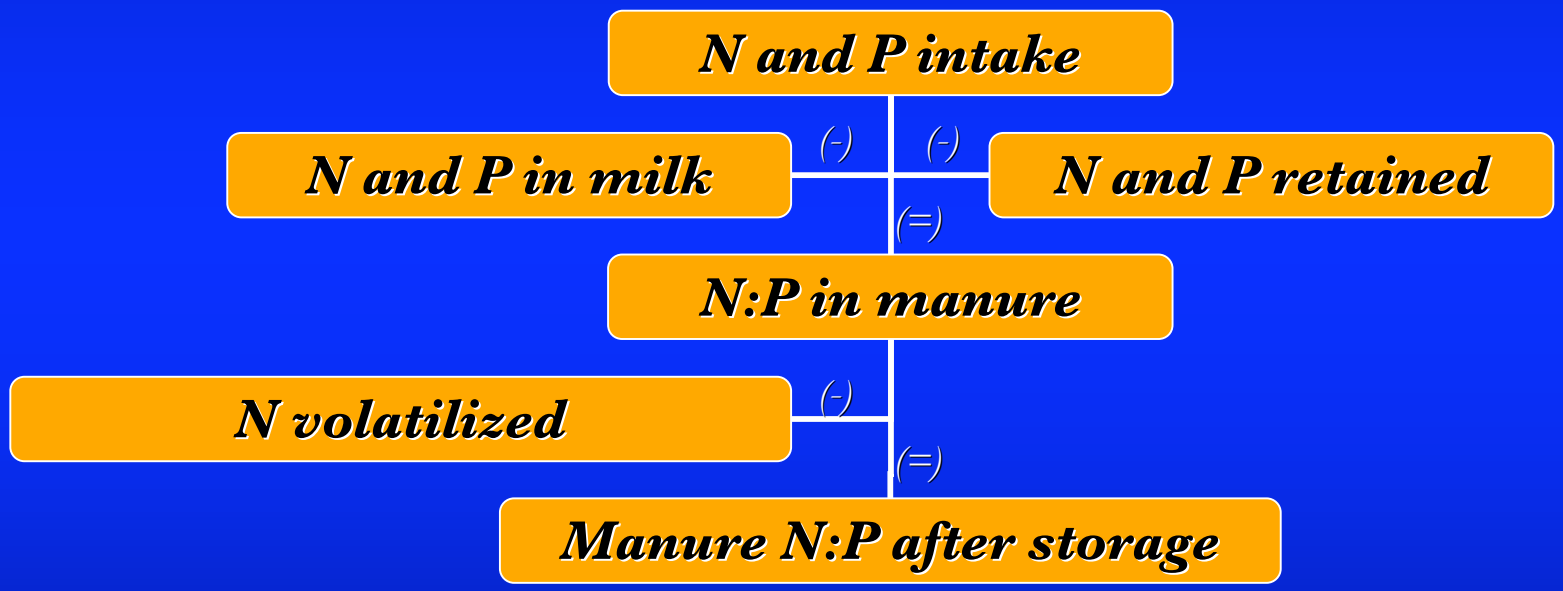
N and P flow


N and P intake
(-)
(-)
N and P in milk
N and P retained
(=)
N:P in manure
(-)
N volatilized
(=)
Manure N:P after storage

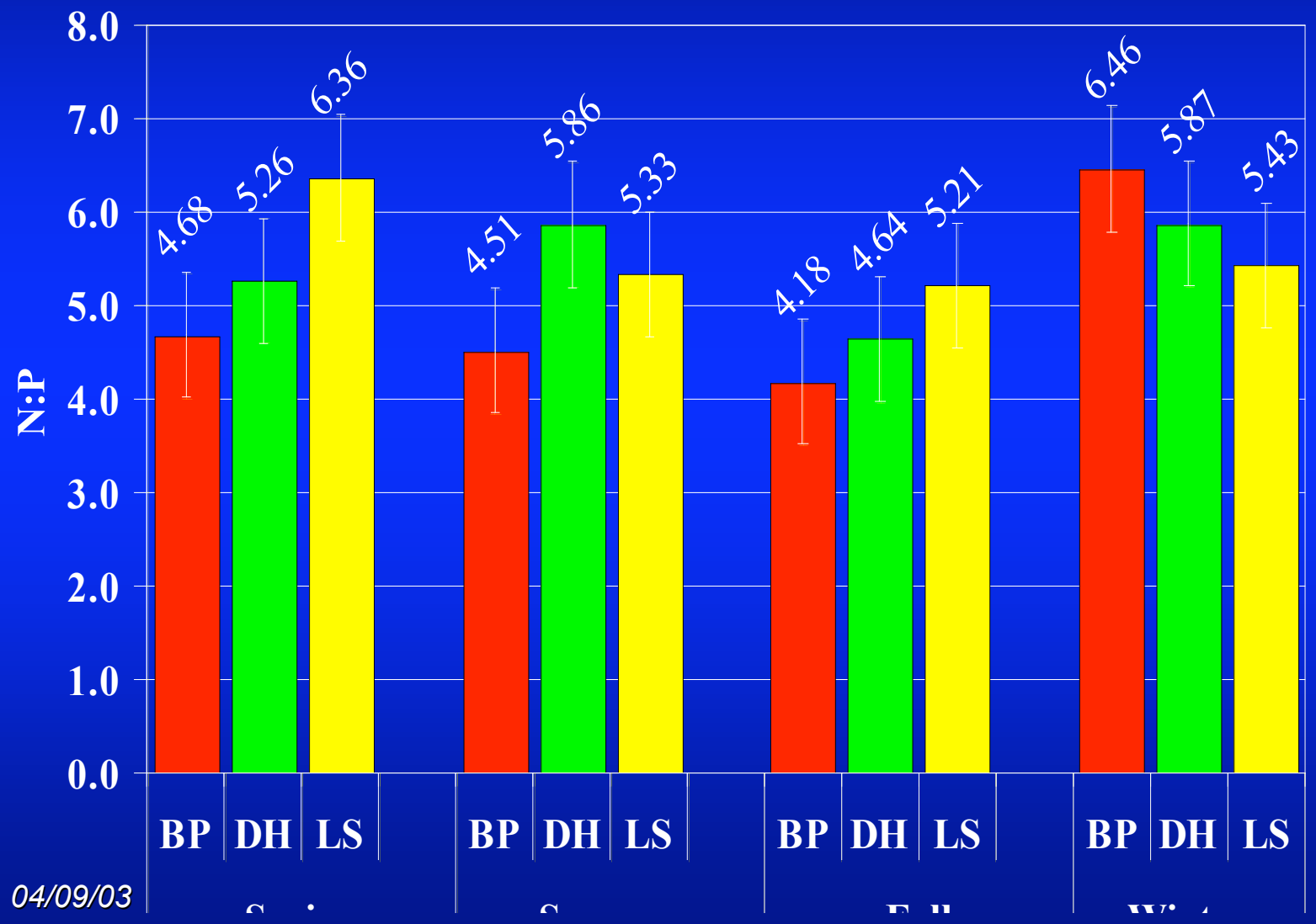
Data-set analysis

- 1496 analyses from:
  - Minnesota;
  - Pennsylvania;
  - Wisconsin.

Data-set analysis

- Characterization:
  - Manure management practice;
  - Liquid slurry storage loading method;
  - Liquid slurry storage coverage;
  - Type of cow bedding used;
  - Season.

Data-set – Storage management



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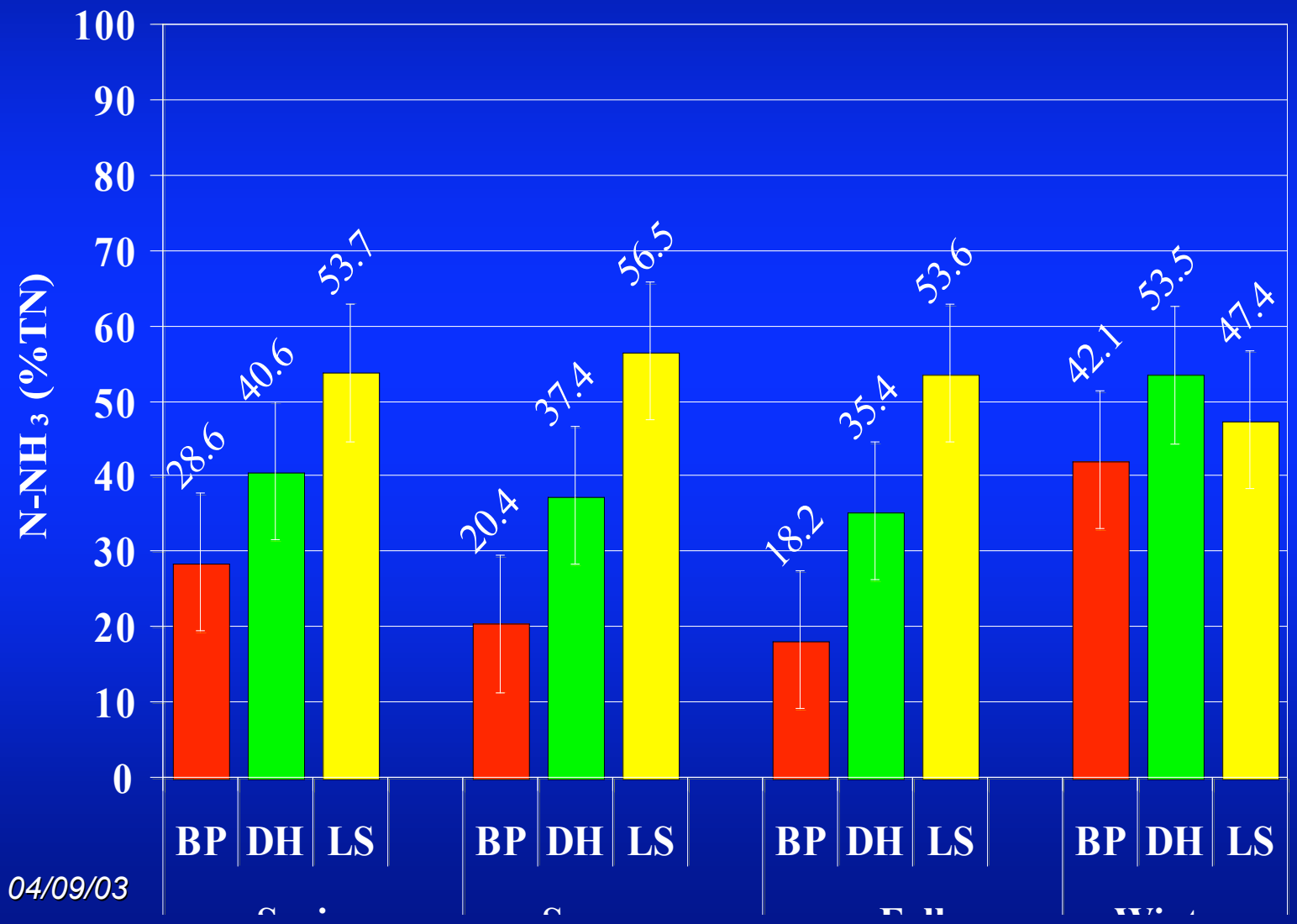
Data-set – Percent of N-NH_3 by manure storage management



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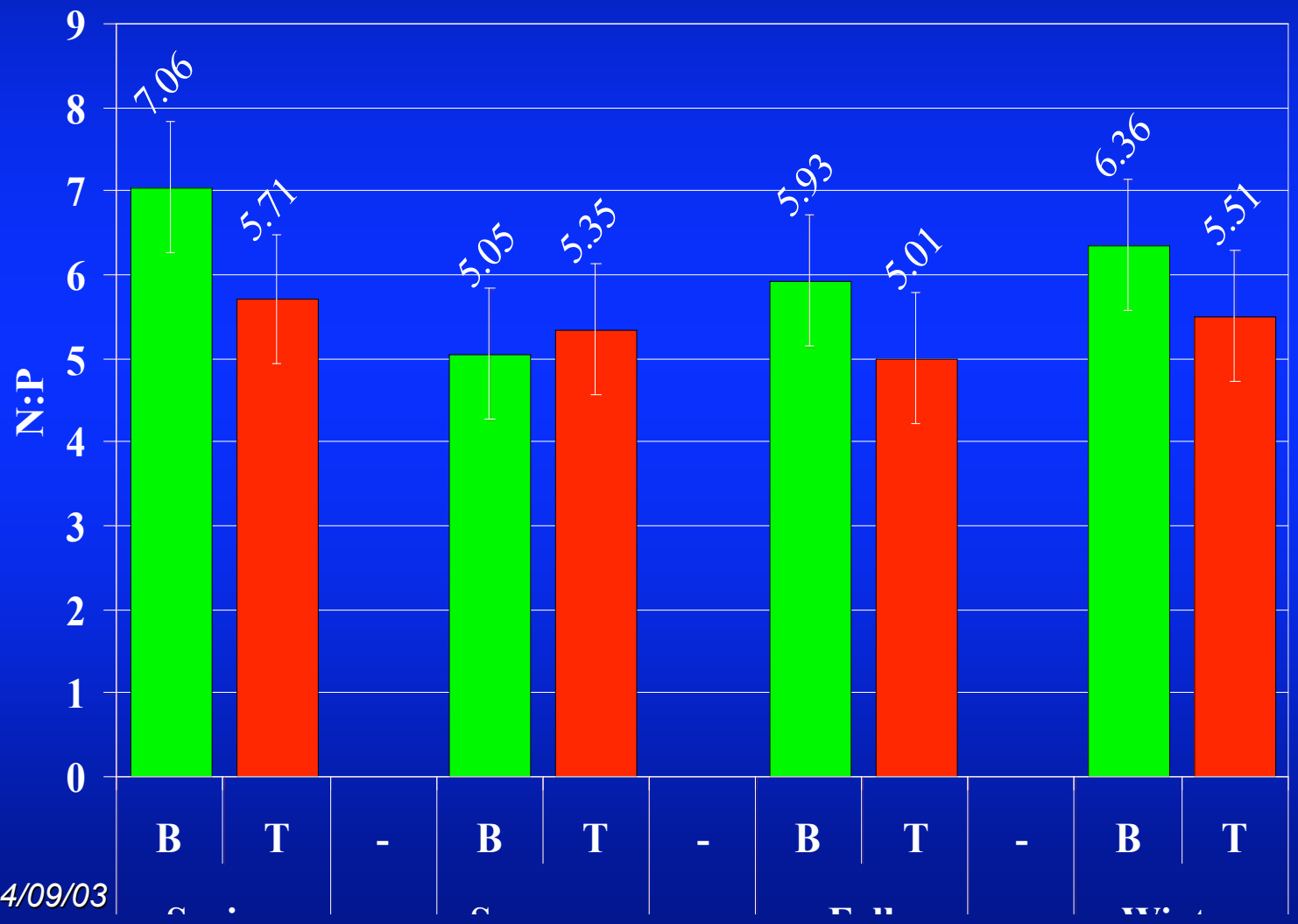
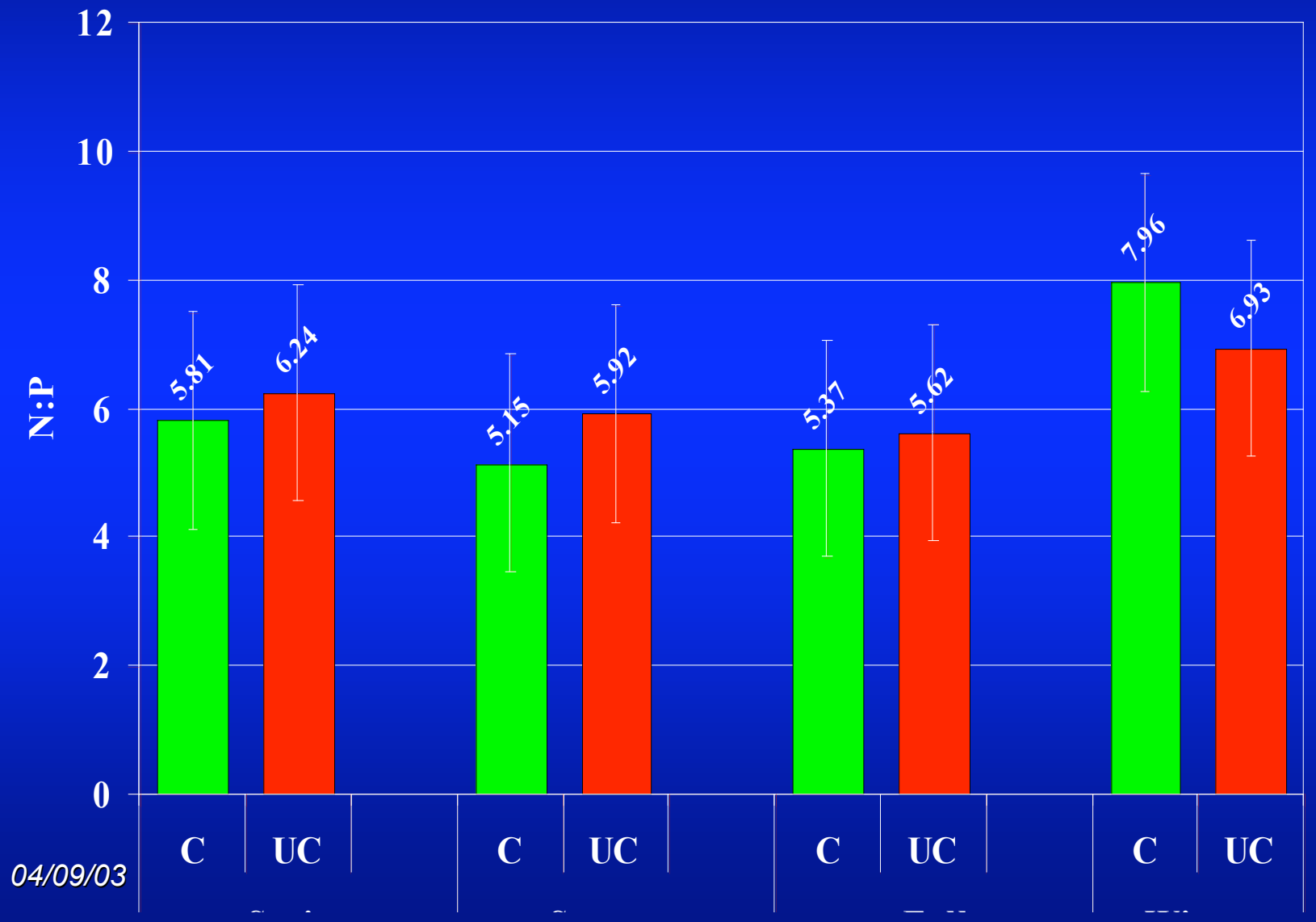
Data-set – Storage loading method



Data-set – Storage coverage



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On-Farm Estimations

- Objective
  - To estimate N disappearance from dairy manure from excretion until storage is emptied using P as a marker (N to P ratio).

On-Farm Estimations

- Materials and methods
  - 13 farms were selected;
  - Samples collected:
    - Manure samples: collected throughout emptying of storage facility;
    - Sampling period: March 27th through May 29th 2001

On-Farm Estimations

- Materials and methods
  - Information:
    - Diet nutrient composition (CP and P)
    - Housing (type and management);
    - Milk records and diet composition (N and P);
    - Manure storage (type and management);
    - Hauling schedule.

On-Farm Estimations

- Materials and methods
  - Sample processing was similar to that of Validation Protocol;
  - TN analyses were done in half of the sub-samples that were lyophilized.

On-Farm Estimations

- Results

	pH	T (^{o}C)	DM (%)	TN (%DM)	Ash (%DM)	P (%DM)	N:P
Overall avg	7.31	14.98	12.28	3.33	36.7	0.63	5.54
Sand bedding	7.40	15.6	15.2	2.79	51.2	0.47	5.91
Sawdust bedding	7.19	14.1	8.73	3.99	19.2	0.81	5.09
Stdev	0.48	5.30	4.38	0.82	17.4	0.21	0.82
CV	6.58	35.4	35.7	24.6	47.4	33.5	14.9
Max	8.52	23.7	19.8	4.34	58.3	0.92	6.49
Min	6.85	6.34	6.73	1.74	17.1	0.36	4.03

FARM	4	5	6
Nutrients intake (kg/cow/d)			
TN	0.742	0.707	0.730
TP	0.112	0.110	0.116
Nutrients secreted in milk (kg/cow/d)			
Milk N	0.168	0.177	0.208
Milk P	0.031	0.032	0.038
Nutrient excreted in manure (kg/cow/d):			
TN (g)	0.574	0.531	0.522
TP (g)	0.081	0.078	0.078
N/P	7.05	6.80	6.72
Manure Analyses			
TN (%DM)	2.881	4.337	3.649
TP (%DM)	0.521	0.814	0.586
N/P	5.39	5.51	6.45
% estimated N loss	23.5	19.0	4.0
Scraping frequency	2	-	2
Bedding	Sand	Sawdust	Sand
Manure storage	Top loaded pit	Slatted floor w/ pit underneath barn	Top loaded pit
Storage period	2-4wks	6mo	24h

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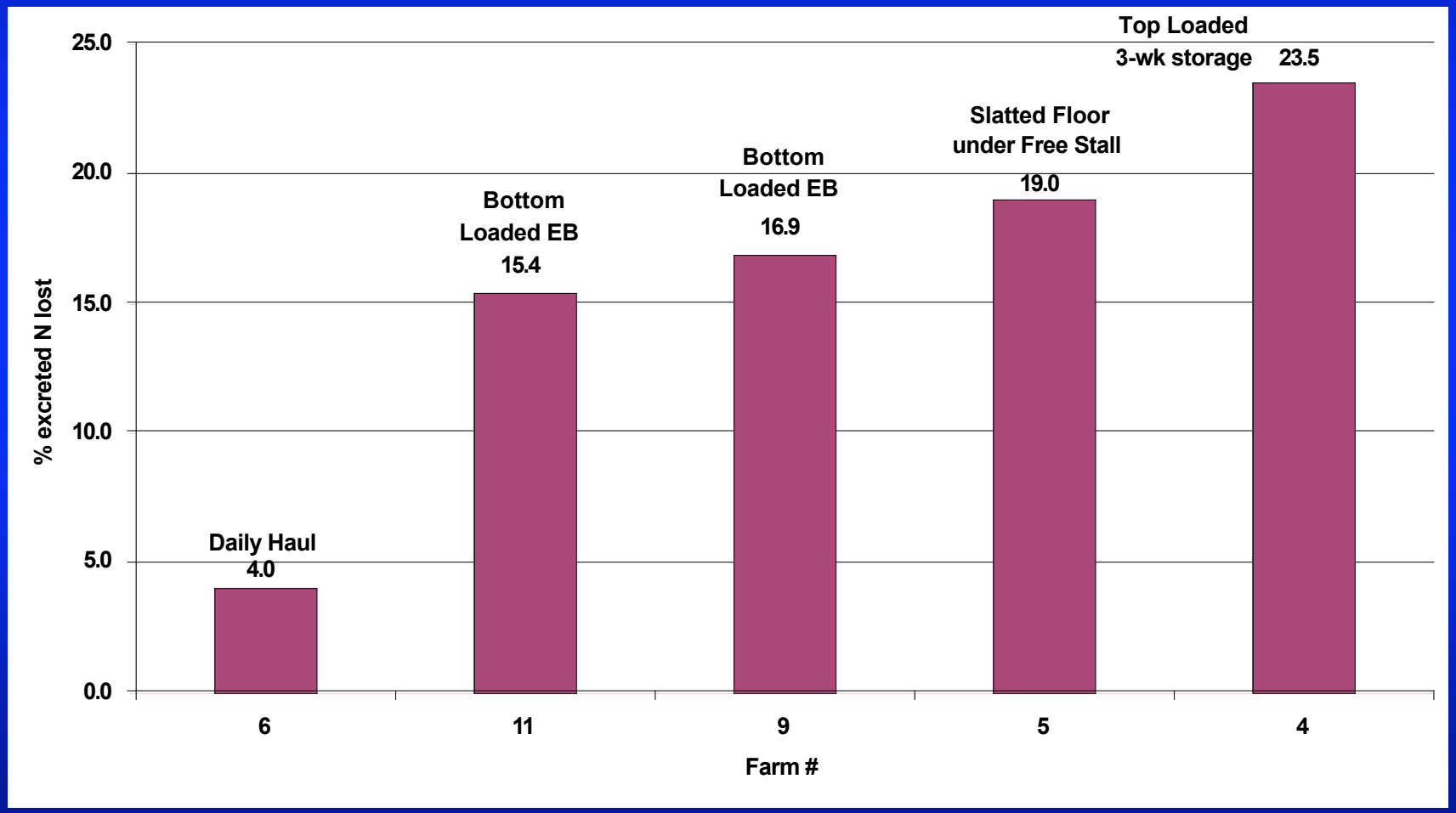
On-Farm Estimations of Nitrogen Losses Through Storage (% excreted N)



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Free stall – Pilot trial

Moreira, V. R., H. H. B. Santos, and L. D. Satter

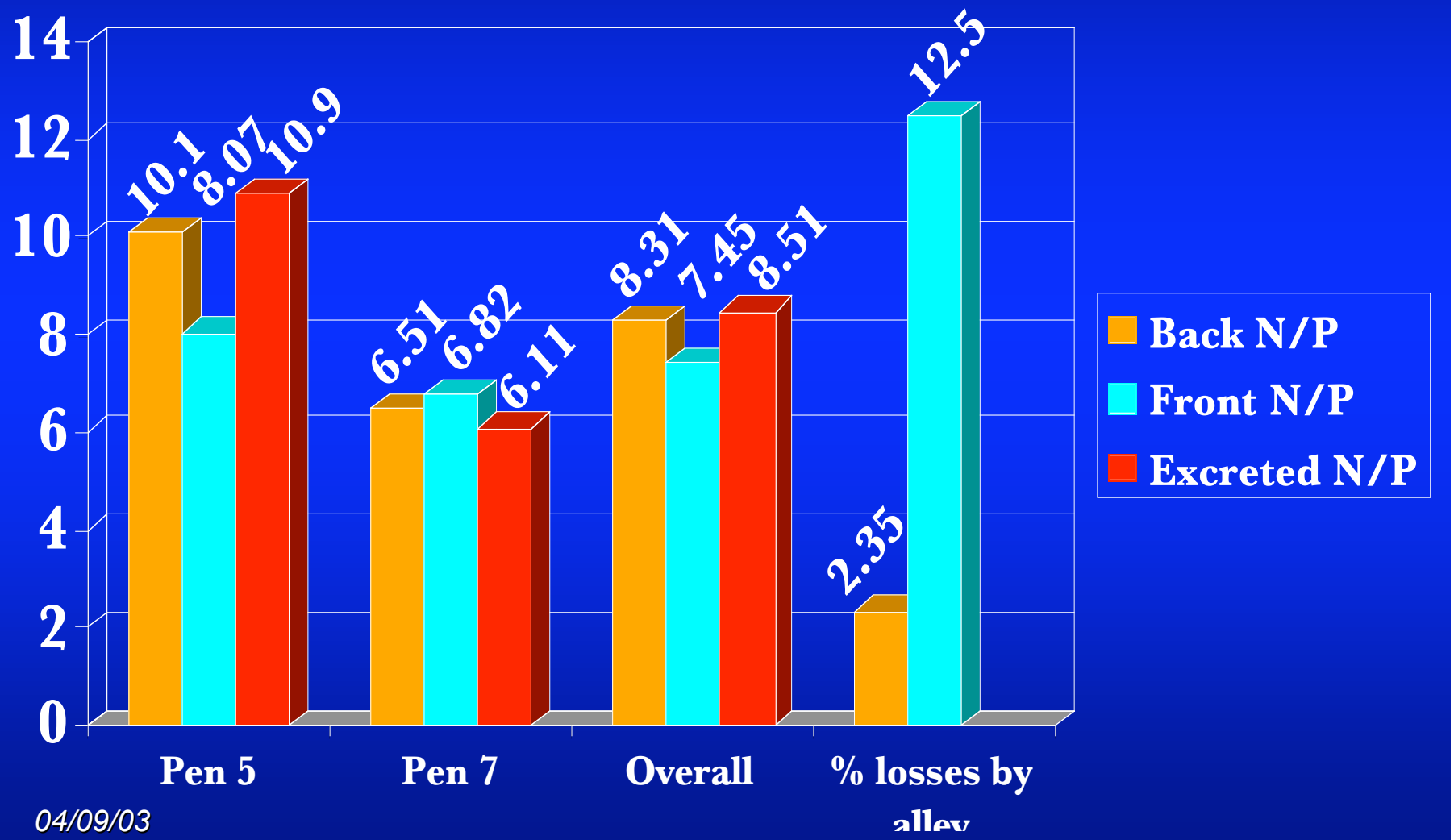
- Objectives
  - To evaluate the use of N to P ratio for estimating N disappearance from manure;
  - To develop a methodology for sampling and processing manure from free-stall floor;
  - To determine N disappearance from free-stall.

Free stall – Pilot trial

- Materials and methods

	Free-stall
Dates	Feb 9-10th 2001
# Groups (pens)	2
# Cows	96 early to mid-lactation dairy cows
Diets	2 (P = .38 & .55%DM; same N=3.08%DM)
DMI	Estimated
MY	Individually (35 and 33.4kg/cow/d; CP=3.10%)
# scraping per day	6-10 (run automatic and manually)
Sampling	3x (7:00pm; 1:00am; 9:00am)

Free stall – Pilot trial



Free stall – Pilot trial Conclusions

- Care should be exercised to minimize urine contamination between pens;
- It seems possible to estimate N loss from dairy manure in free-stall barn using N to P ratio;
- Due to different urine/feces ratio of excretion in front and back alleys, N loss can only be presented as a range.
- N loss appear to be low in winter (air T <10°C).

N to P – Scraping Summer – 2001

Hypothesis

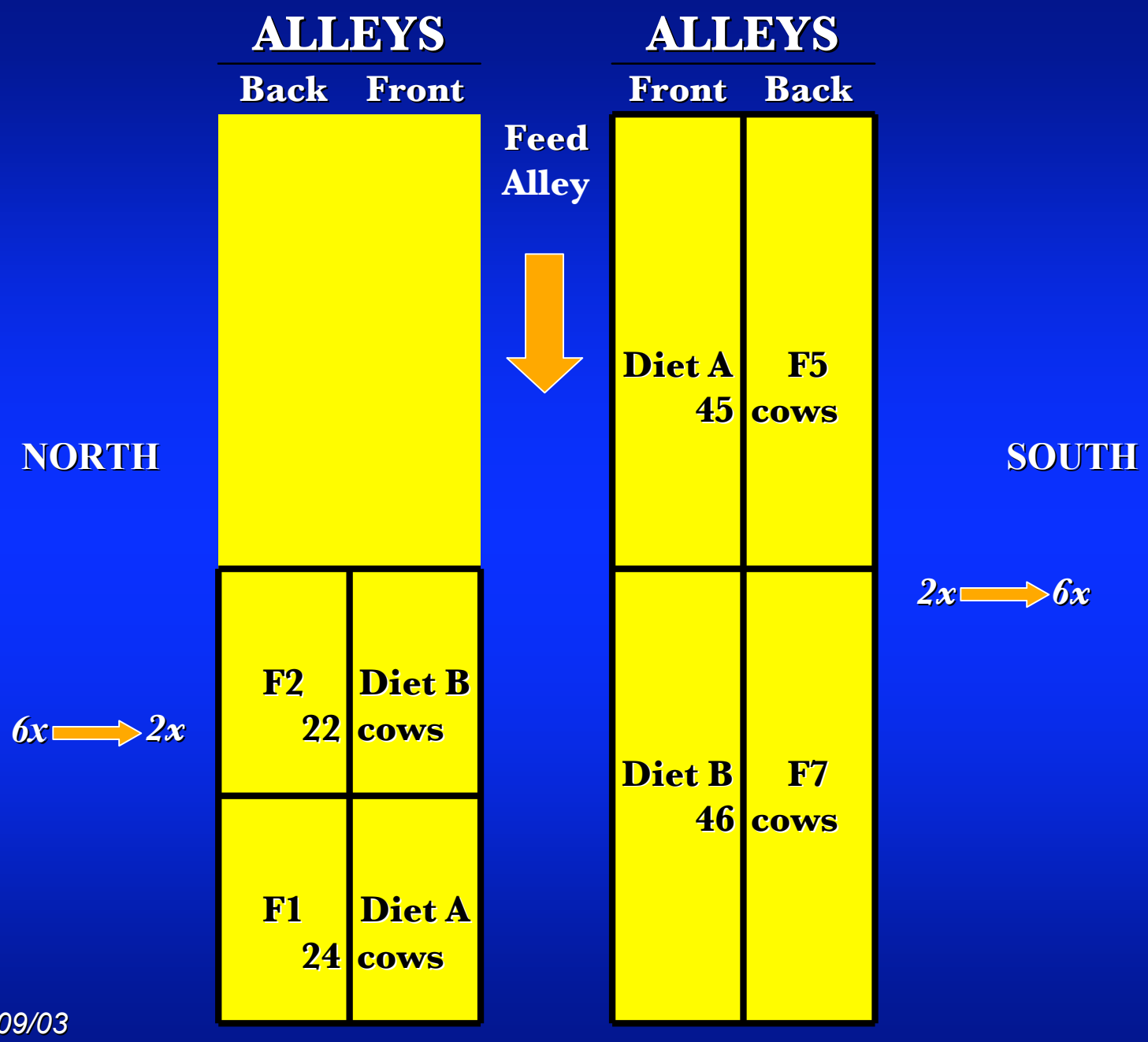
- Scraping frequently will reduce N loss during Summer.

Objective

- To evaluate the effect of scraping frequency on N disappearance, as estimated by N to P ratio.

Materials and Methods

- Treatments:
  - Floors were scraped 2 or 6-times a day;
  - Times (2 - 24h periods):
    - 2x: 8am and 7pm;
    - 6x: 9am, noon, 3pm, 6pm, 11pm, 4am.
- Design and schedule:
  - Cross-over design;


ALLEYS
Back
Front
ALLEYS
Front
Back
Feed Alley
NORTH
SOUTH
Diet A 45
F5 cows
2x
6x
F2 22
Diet B cows
6x
2x
Diet B 46
F7 cows
F1 24
Diet A cows

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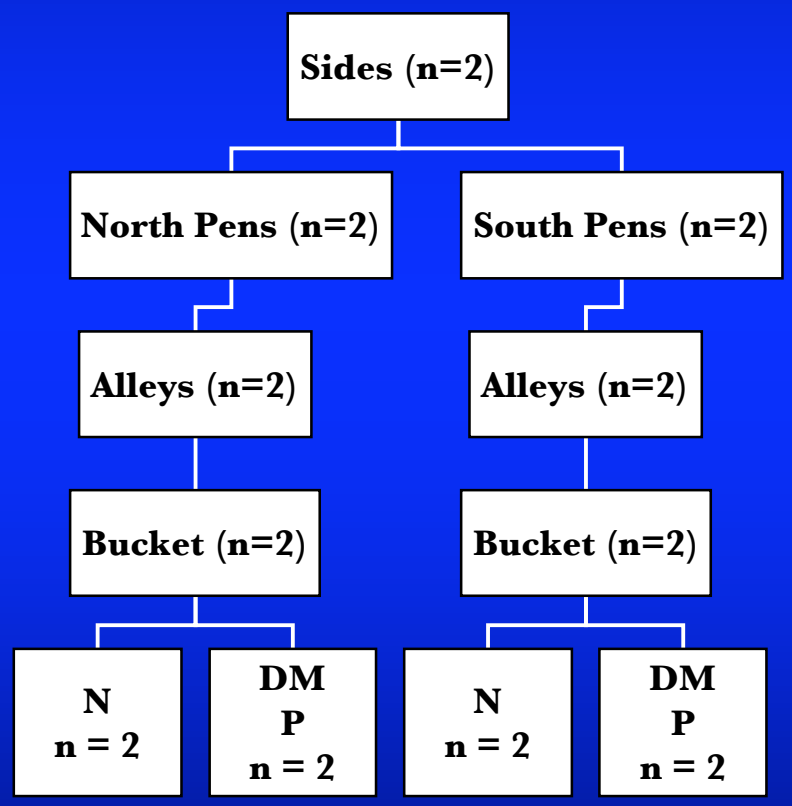
Materials and Methods

- Cows & diets:
  - 137 mid-lactation dairy cows;
  - Milk yield = 30-32kg/cow/d (3.20%CP);
  - Diet: P = .38 & .55%DM; same N = 3.08%DM;
  - DMI was calculated based on NRC (2001) model.

Sampling Protocol

Sampling Free-Stall

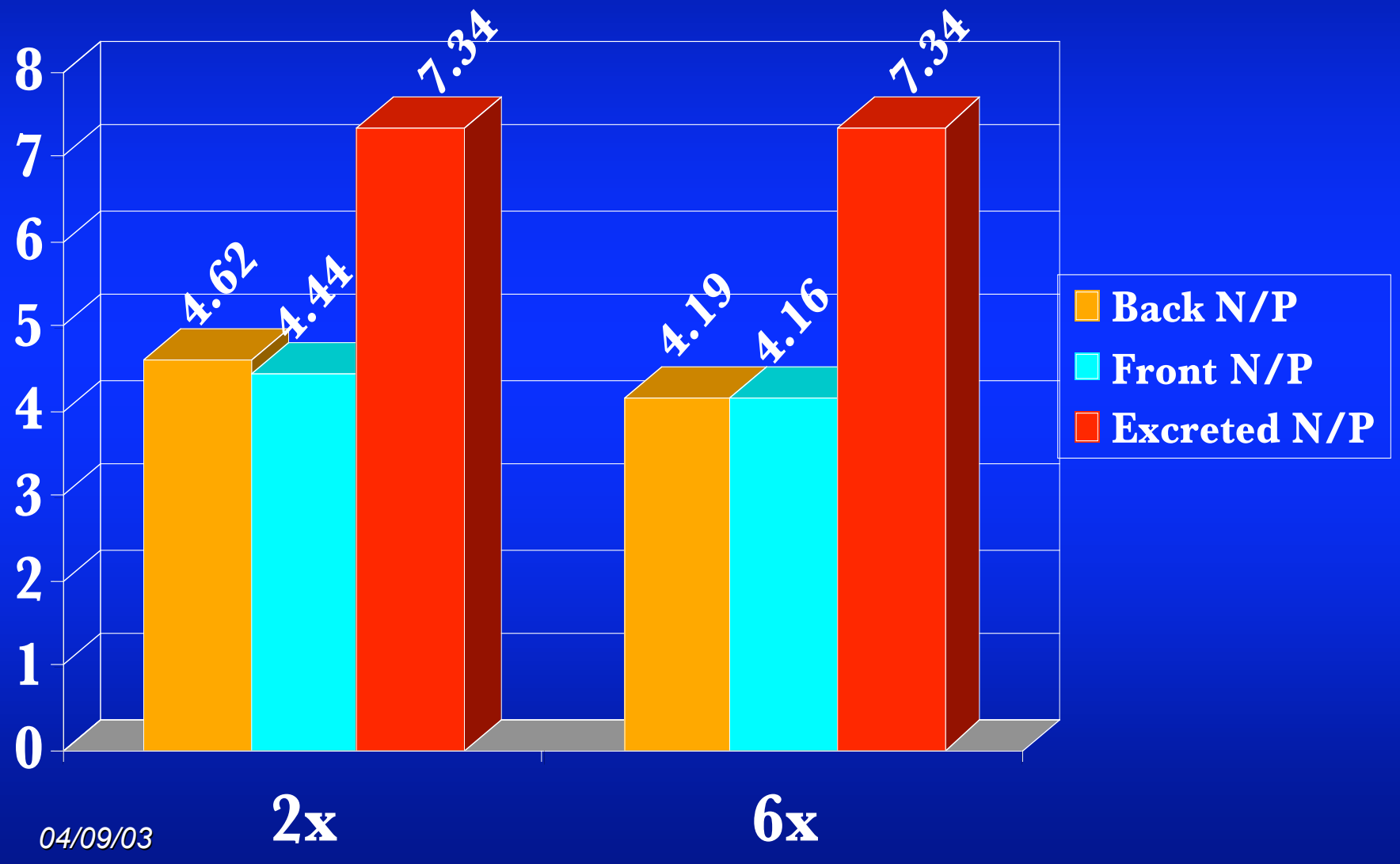


- Processing and analyses:
  - For N:
    - Acidified (67%H_2SO_4);
    - Frozen immediately;
    - Freeze-dried and ground 1mm screen.
    - Leco N analyzer.
  - For P:
    - DM analyses;
    - Ground 1mm screen;
    - DCP analyses.

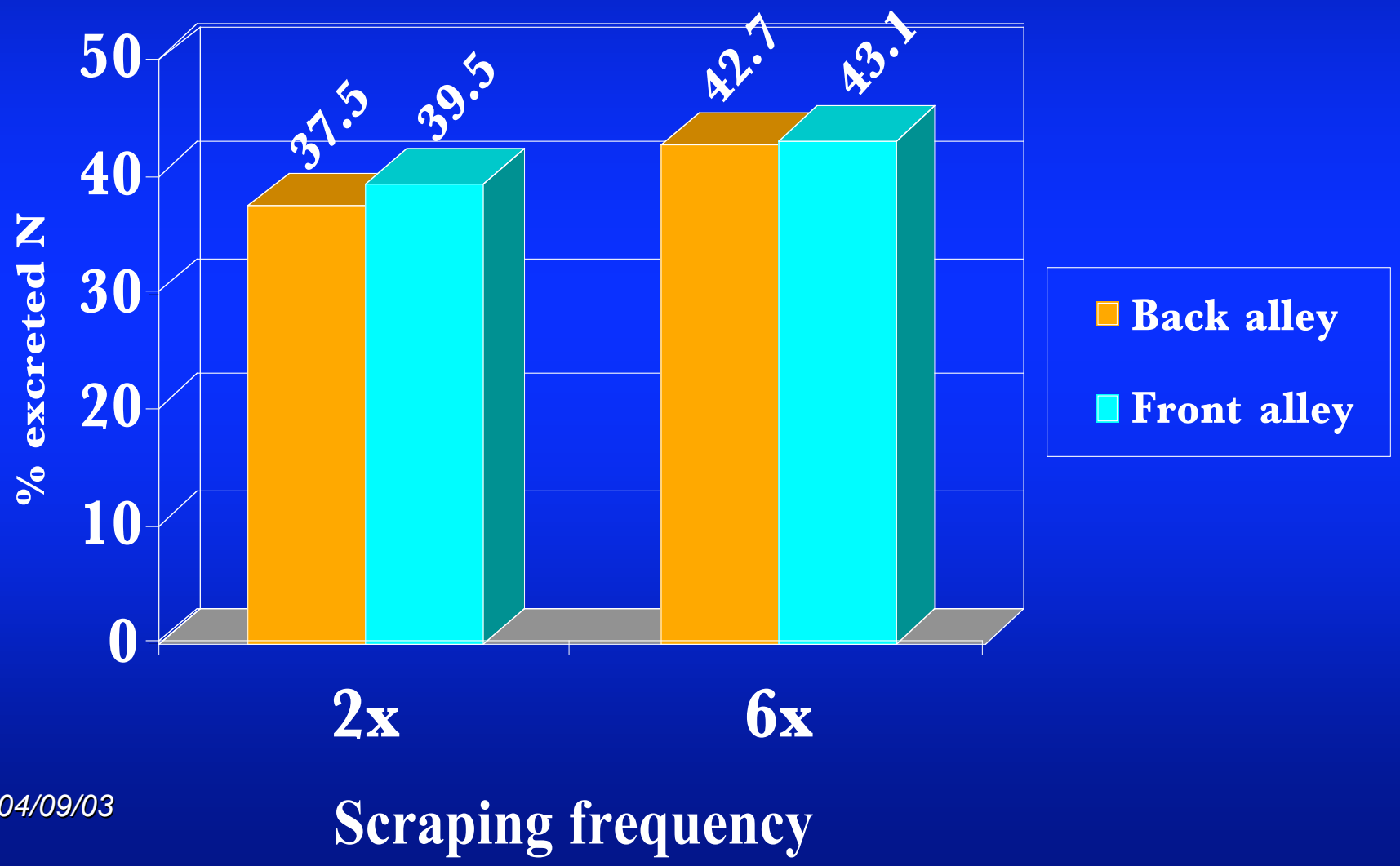
Results

Manure analyses	Scraping frequency (Freq)				SEM	Effects ($P \leq$)		
	2x		6x					
	Front alley	Back alley	Front alley	Back alley		Freq	alley	Day *Freq
pH	7.73	8.15	7.84	8.04	0.14	1.00	0.01	0.43
Manure T, ^{o}C	21.7	23.2	22	22.3	0.52	0.48	0.29	0.23
Dry matter, %	10.7	11.6	11.4	11.9	0.48	0.26	0.01	0.71
N, %DM	4.09	4.04	3.86	3.86	0.1	0.03	0.75	0.32
Ash, %DM	16.5	17.9	16.1	16.7	0.51	0.11	0.01	0.05
P, %DM	0.95	0.93	0.96	0.95	0.04	0.67	0.54	0.05
N:P	4.44	4.62	4.16	4.19	0.17	0.03	0.36	0.04

Estimating N Loss



Estimating N Loss



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Conclusion

Increased scraping frequency does not seem to improve N retention in dairy manure under summer conditions;

Publications and Presentations

- Lab Datasets: ADSA2002;
- Frequency of scraping: ADSA2003, Feedstuffs (Jul/03); Dairy Herd Management (Sep/03);
- On-farm: Discovery Conference (Apr/02);
- Model of N volatilization: Chapter on Ammonia Emissions from Confinement Dairy Operations.