Managing Crap
What's Next in Manure?

themanurescoop.blogspot.com

@DrManure

Dr. Daniel Andersen
Agricultural & Biosystems Engineering
dsa@iastate.edu

IOWA STATE UNIVERSITY

Outline

- Manure and Nutrient Flows
- Iowa Nutrient Budgets
- Selecting Application Rates
- **Manure Variability and Uncertainty**

Manure System Stages and Objectives

Stage 1: House Animals & Contain Manure

The structures and areas where the animals eat, sleep, and defecate.
Manure should be contained and clean water diverted to avoid manure contact.

Stage 2: Manure Collection & Water Recycle

Manure can be collected via scraping, flushing, belts, gravity fall, or similar.
Pumping from temporary holding areas or conveyance of flush water.
Belt movement or front-end loader transport of solid manure or manure solids.

Stage 3: Manure Storage & Treatment

Storages: lagoons, pits, tanks, holding ponds, stacking sheds, stockpiles, etc.
Treatments: anaerobic & aerobic digestion, solid separation, nutrient recovery, etc.

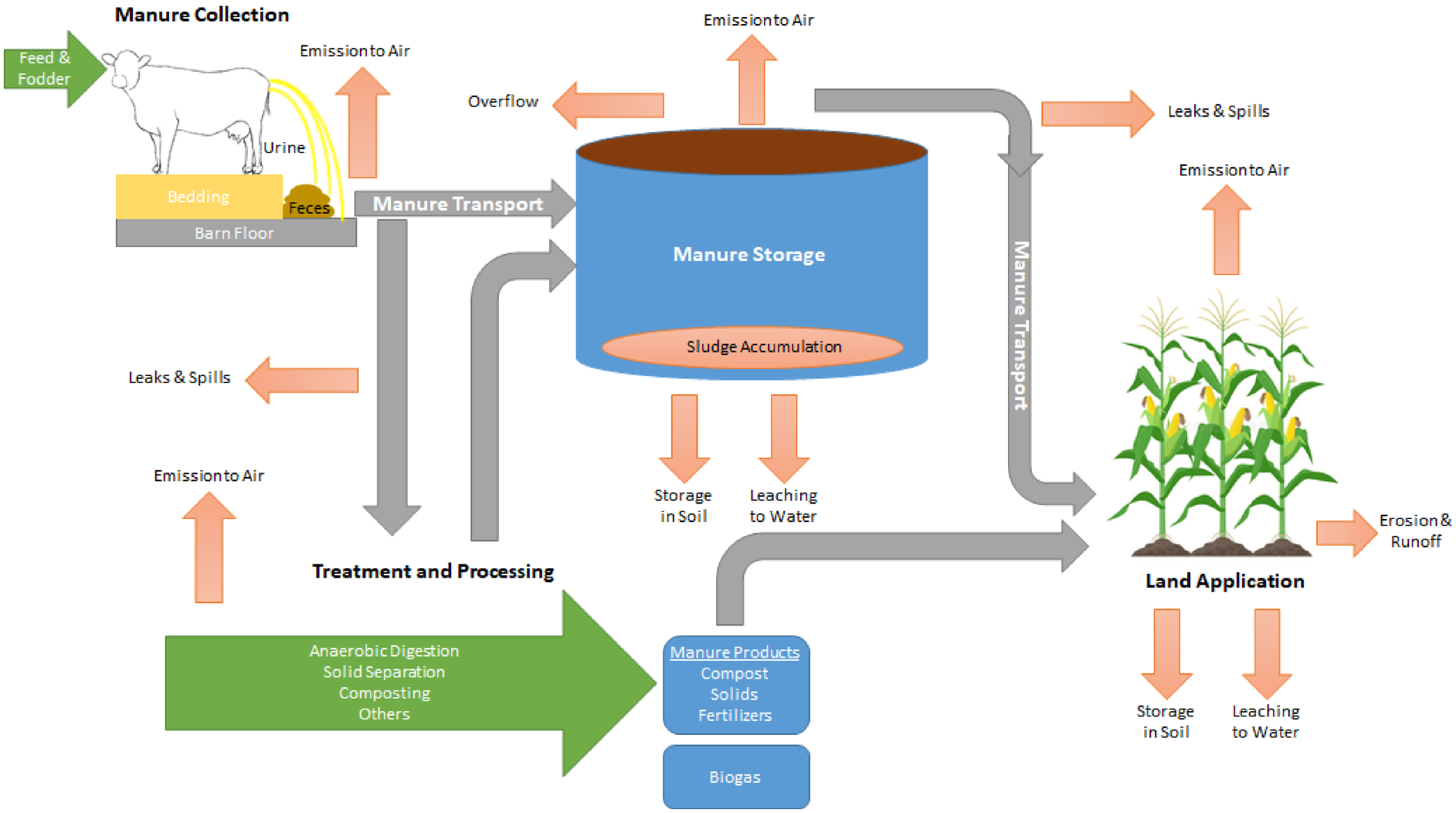
Stage 4: Manure Transport to Utilization

Hauling or pumping systems that move manure to the application field.

Stage 5: Manure Application or Utilization

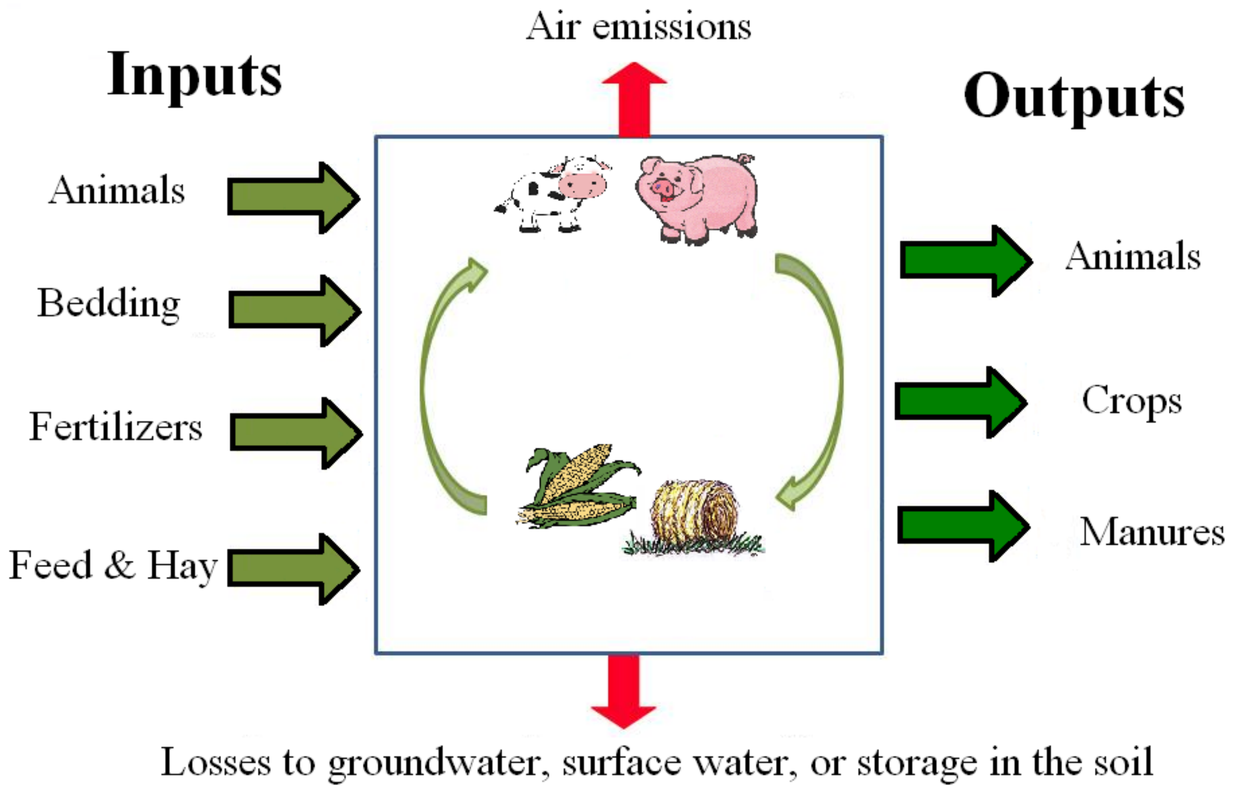
Land application to a crop or pasture.
Sale of fertilizer or compost.

Understanding Manure Systems



Fundamental of Nutrient Management

Is My Livestock or Poultry Operation Concentrating Nutrients?



Determining Manure Application Rates

- Two parts
  - **Supply (how much is in the manure)**
    - Concentration
    - Availability
    - Volatilization
  - **Demand (how much does the crop need)**
    - Crop Rotation
    - Weather
    - Soil
- Nitrogen or Phosphorus Limited

Nutrient Supply

- Nutrient Availability
- Two types of nutrients in manure
  - **Organic**
  - **Inorganic**
- Organic nutrients must be mineralized to inorganic form to become available
  - Depends on manure type, soil temperatures, moisture conditions, storage length, etc.
  - Table values used to determine amount that will become available (for your assignment see manure nutrient utilization)

Iowa Nitrogen Availability Recommendations

Nitrogen Availability for Different Manure Sources			
	First Year	Second Year	Third Year
	Percent of Total Nitrogen Applied		
Beef Cattle (solid or liquid)	30-50	10	5
Dairy (solid or liquid)	30-50	10	5
Liquid Swine (anaerobic pit)	90-100	0	0
Liquid Swine (anaerobic lagoon)	90-100	0	0
Poultry (all species)	50-60	0-10	0

From ISU publication PMR 1003 (Revised May 2016).

Mineralized organic nitrogen.

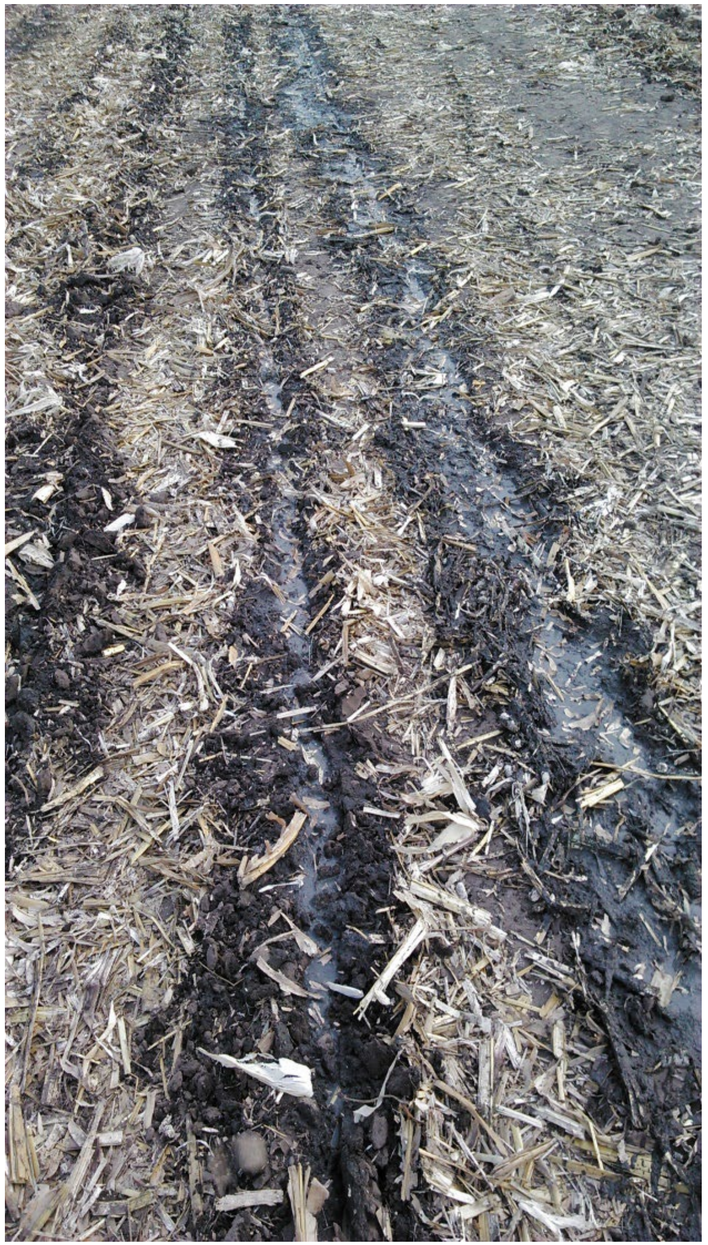
Amount mineralized (released to crops) during first cropping season after application of animal manure. Boxed value refers to Example 10-3.

Manure type	Manure handling	Mineralization factor
Swine	Fresh	0.50
	Anaerobic liquid	0.35
	Aerobic liquid	0.30
Beef	Solid without bedding	0.35
	Solid with bedding	0.25
	Anaerobic liquid	0.30
	Aerobic liquid	0.25
Dairy	Solid without bedding	0.35
	Solid with bedding	0.25
	Anaerobic liquid	0.30
	Aerobic liquid	0.25
Sheep	Solid	0.25
Poultry	Deep pit	0.60
	Solid with litter	0.60
	Solid without litter	0.60
Horses	Solid with bedding	0.20

Supply Nitrogen Volatilization

Correction Factors After Land Application of Manure		
Application Method	**Incorporation**	**Correction Factor**
Direct Injection	---	0.98-1.00
Broadcast (liquid/solid)	Immediate	0.95-0.99
Broadcast (liquid)	None	0.75-0.90
Broadcast (solid)	None	0.70-0.85
Irrigation	None	0.60-0.75

From ISU publication PMR 1003 (Revised May 2016).



Calculating Manure Nutrient Supply

Available N = Total N x Availability x Volatilization

Pig Manure

60 lb N/1000 gallons

Availability 90%

Injection 99% retained

60 lb N/1000 gallons x 0.9 * 0.99 =

53 lb available N/1000 gallons

Nutrient Demand

2 Methods

Yield Goal Method

- supply amount expected to be removed with harvested crop
- Used in Iowa Manure Management Plans as the maximum limit

Crop Response Method

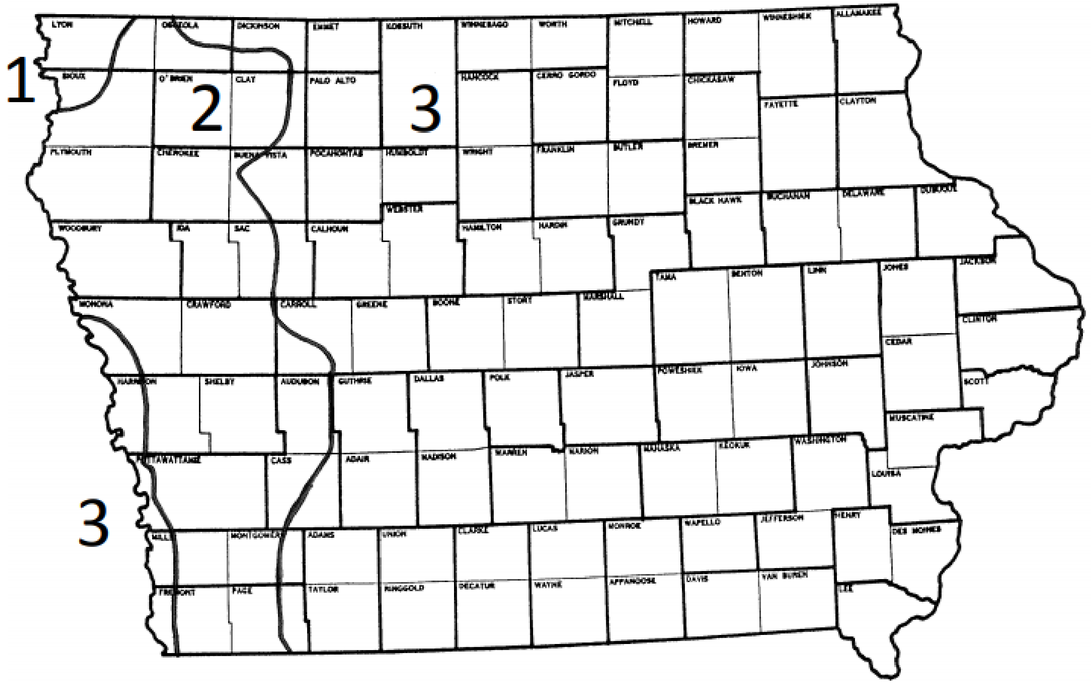
- Determines the optimal range based on cost of obtaining nutrients and crop response to nutrient

Yield Goal

Manure Management Plan Form
Appendix A5: Crop Nitrogen Usage Rate Factors for Various Crops[4] Page 5

Corn	Zone 1	0.9 lb/bu	Orchardgrass	38.0 lb/ton
	Zone 2	1.1 lb/bu	Tall fescue	38.0 lb/ton
	Zone 3	1.2 lb/bu	Switchgrass	21.0 lb/ton
Corn silage		7.5 lb/ton	Vetch	56.0 lb/ton
Soybeans		3.8 lb/bu	Red clover	43.0 lb/ton
Oats		0.75 lb/bu	Perenial ryegrass	24.0 lb/ton
Alfalfa		50.0 lb/ton	Timothy	25.0 lb/ton
Wheat		1.3 lb/bu	Wheat straw	13.0 lb/ton
Smooth bromegrass		40.0 lb/ton	Oat straw	12.0 lb/ton
Sorghum-sudan		40.0 lb/ton		

The following map outlines the three zones for the corn nitrogen usage rates indicated in the Table 4. Zone 1 corresponds to the Moody soil association. Zone 2 corresponds to the Marshall, Monona-Ida-Hamburg , and Galva-Primghar-Sac soil associations. Zone 3 corresponds to the remaining soil associations.



How do we pick reasonable yields?

5-year average + 10%
Or Ave of 4 of the last five years

Manure Management Plan Form
Appendix A8: Iowa Ag Statistics County Corn and Soybean Yield Averages, 2013-2017 Page 7

	Corn			Soybeans		
County	5-yr. avg. yield (bu/ac)	5-yr. ave. yield + 10% (bu/ac)	Avg. yield of 4 highest (bu/ac)	5-yr. avg. yield (bu/ac)	5-yr. ave. yield + 10% (bu/ac)	Avg. yield of 4 highest (bu/ac)
Adair	170	187	178	50	55	54
Adams	171	188	177	50	55	52
Allamakee	182	200	187	53	58	53
Appanoose	158	174	170	46	51	50
Audubon	190	209	198	55	61	58
Benton	190	209	197	55	60	57
Black Hawk	188	207	194	55	60	56
Boone	186	204	194	52	58	55
Bremer	192	211	200	55	61	57
Buchanan	191	210	197	54	60	56
Buena Vista	185	203	191	54	59	56

Legume Credit

Soybean:

1 lb N per bushel of yield up to 50

(Probably more of a rotation effect, than an N addition to the soil.. But it works)

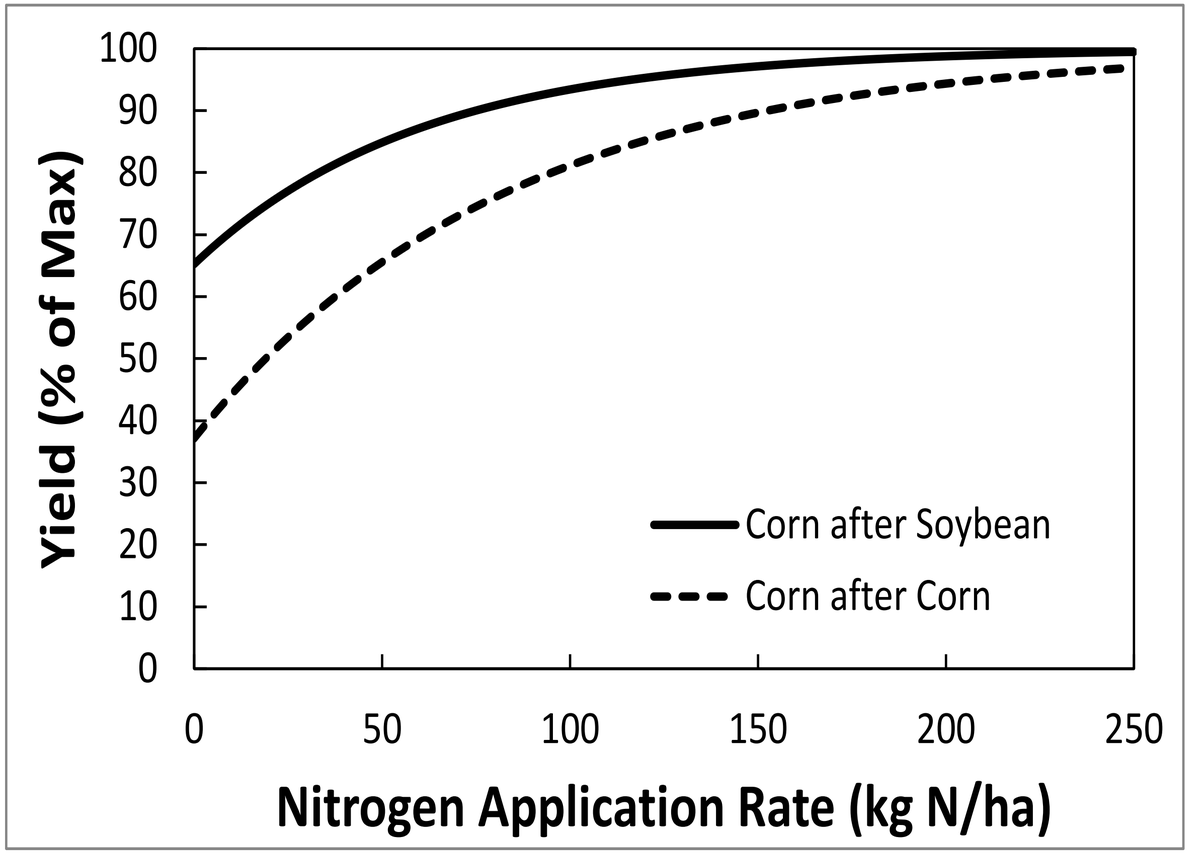
Alfalfa:

50-100% alfalfa = 100-140 lb N/acre

30 lb N/acre 2nd year

20-50% alfalfa = 50-80 lb N/acre

Crop Response (MRTN)



Corn Nitrogen Rate Calculator

Finding the Maximum Return To N and Most Profitable N Rate

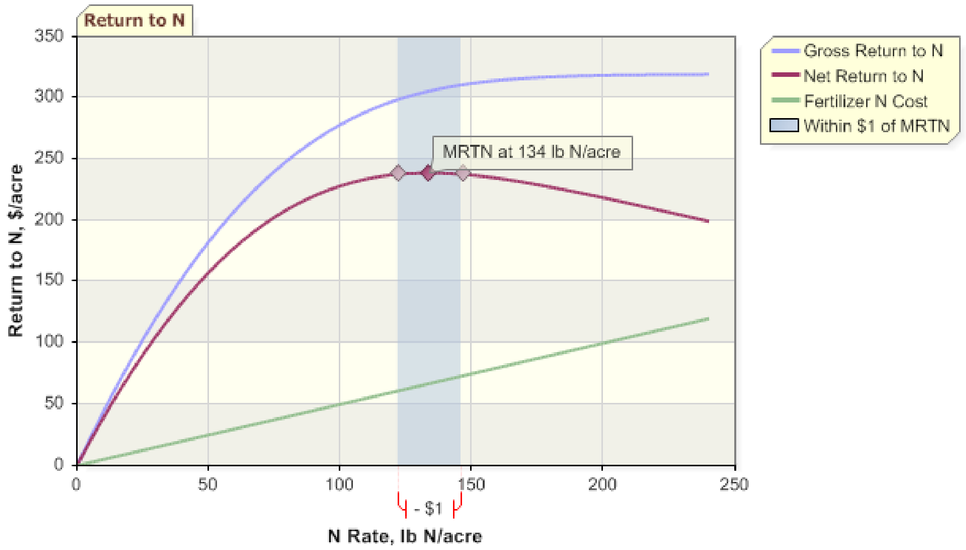
A Regional (Corn Belt) Approach to Nitrogen Rate Guidelines

State: Iowa
Number of sites: 212
Rotation: Corn Following Soybean
Non-Responsive Sites Not Included

Nitrogen Price ($/lb): 0.50
Corn Price ($/bu): 5.00
Price Ratio: 0.10

MRTN Rate (lb N/acre):	**134**
Profitable N Rate Range (lb N/acre):	122 - 146
Net Return to N at MRTN Rate ($/acre):	$238.83
Percent of Maximum Yield at MRTN Rate:	99%
Anhydrous Ammonia (82% N) at MRTN Rate (lb product/acre):	163
Anhydrous Ammonia (82% N) Cost at MRTN Rate ($/acre):	$67.00

Most profitable N rate is at the maximum return to N (MRTN).
Profitable N rate range provides economic return within $1/acre of the MRTN.



Calculating Application Rate

- So if we want 134 lb N/acre and our manure had 53 lb available N/1000 gallons, how much should be apply?

Application Rate = Demand/Supply

134 lb N/acre/ 53 lb N/1000 gallons = 2528 gallons/acre

Manure Example

- You have 700-head beef finishing operation on bedded pack.
- The manure sample said 30 lbs of total N and 45 lbs of P_2O_5 per ton. Assuming you want to apply 150 pounds of nitrogen per acre, and your surface application is nitrogen limited how much should you apply.

- How much phosphorus would be applied? Assuming you make this application every other year, how does that compare to phosphorus removal rates if you are raising 200 bushel per acre corn and 60 bushel and acre soybean?

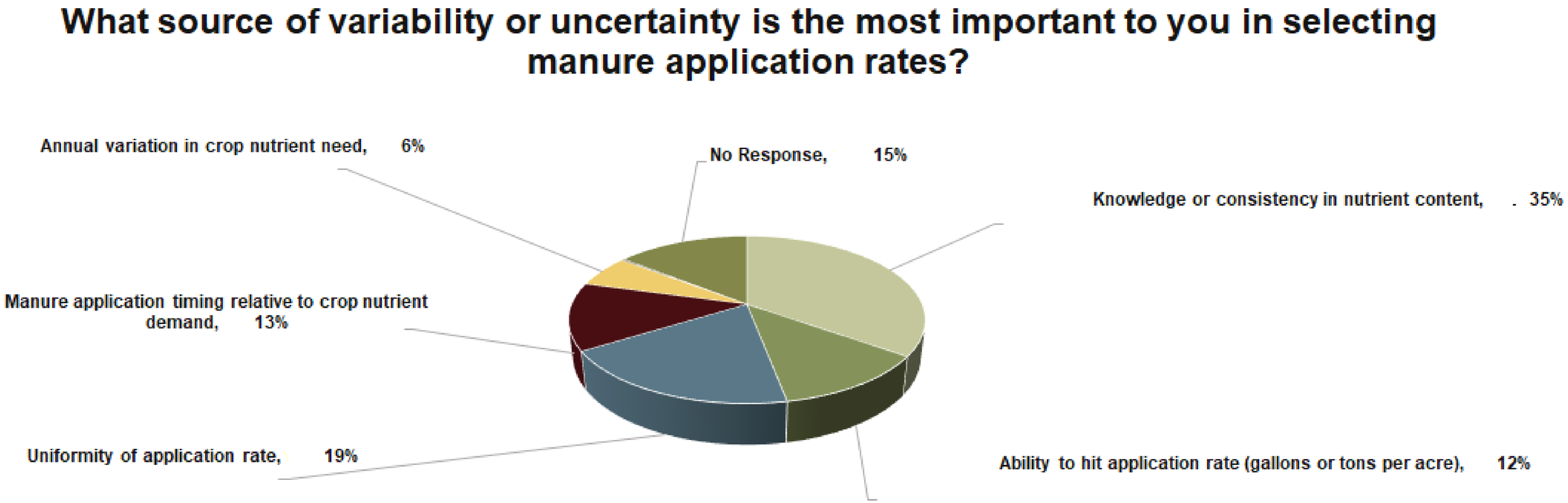
Manure Example

- N Supply
  - 30 lb N/ton
  - First Year Availability 35%
  - Volatilization (22.5%) Retention = 77.5%
  - 30 lb N/ton x 0.35 x 0.775 = 8.1 lb N/ton
- N Demand
  - 150 lb N/acre / 8.1 lb N/ton = 18.5 tons/acre
- Application Rate
  - 150 lb N/acre / 8.1 lb N/ton
- P-Applied
  - 18.5 tons/acre x 45 lb P_2O_5/ton = 833 lb P_2O_5/acre
- P-Removed
  - 200 bu/acre x 0.32 lb P_2O_5/bu + 60 bu/acre x 0.72 lb P_2O_5/bu = 107 lb P_2O_5/acre

Do You Trust Manure?

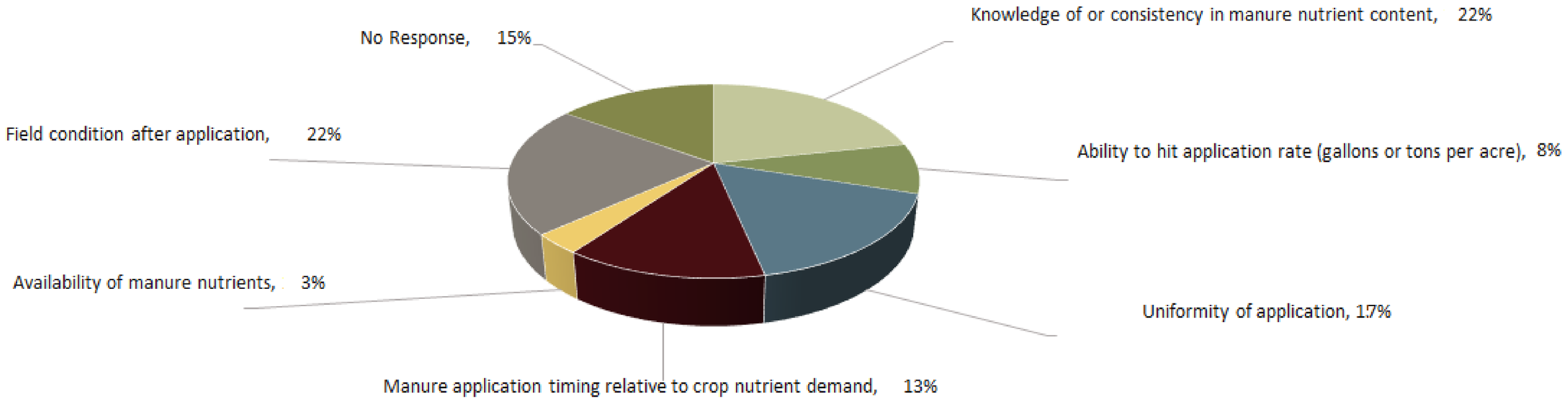
“Every year I’m growing less confident on the N power in manure and would like to be able to just use it for my P needs and apply all commercial N”

What did manure users say?



What did commercial manure applicators say?

What do you consider the most challenging in your role with clients using manure as a fertilizer?



What do I say?

- It doesn’t matter what I say, perception drives reality
- If your client, or you, believe that is where the issue is, that is where you will, and should pursue making an investment
- But, building trust in manure is an important part of YOUR role

Who cares about trust?

- Manure is a fertilizer, if you don’t trust it, you want more N (insurance nitrogen)

- Hopefully farmers (crop advisors) evaluate the season and use information gained to improve next season. That means trusting what happened.

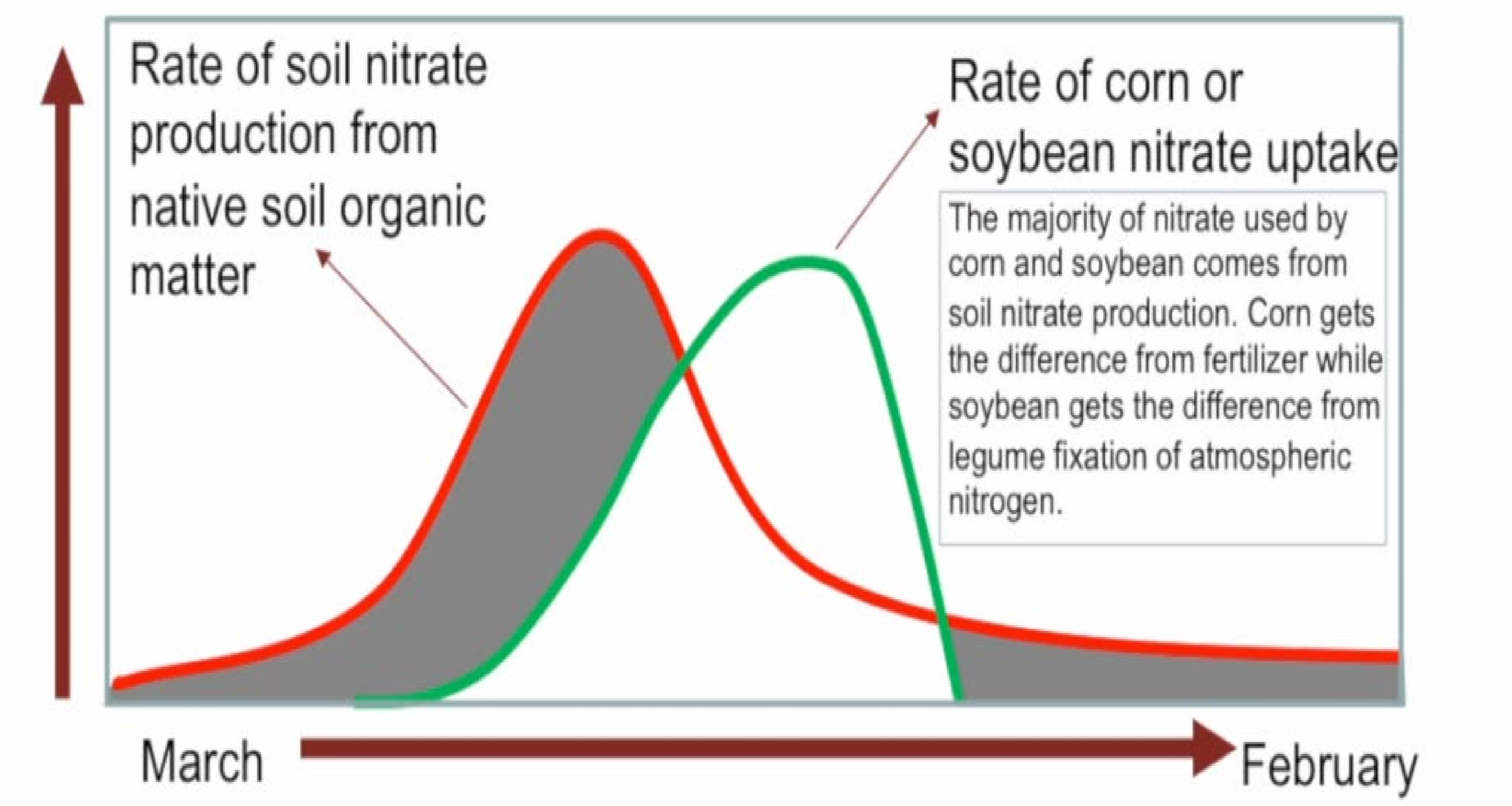
- Should we treat and separate fertilizer, or apply manure? I’ve resisted this approach – it is expensive (both monetarily, in in labor to operate)

But what I actually say*

*subject to change

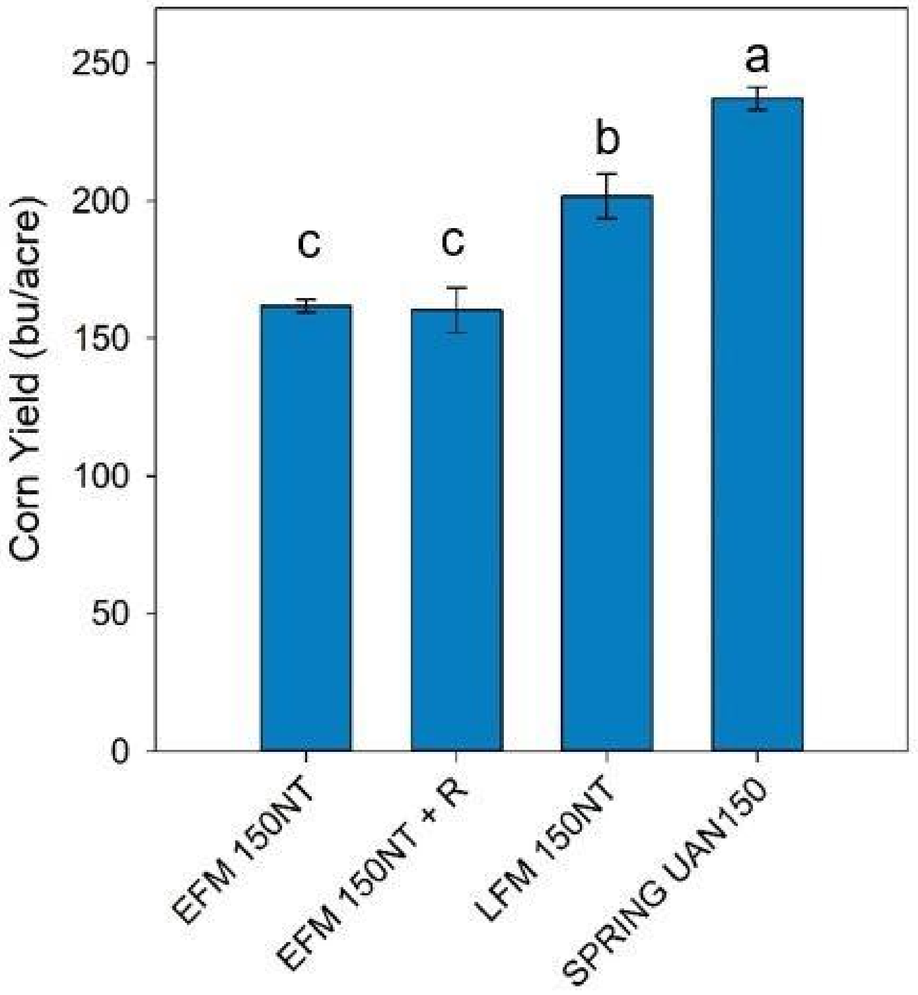
- Variation in Nitrogen Need in a Specific Year
- Ability to hit rate (lower rates)
- *Field conditions after application*
- Timing (except when it doesn’t)
- Uniformity of application
- Nutrient Consistency

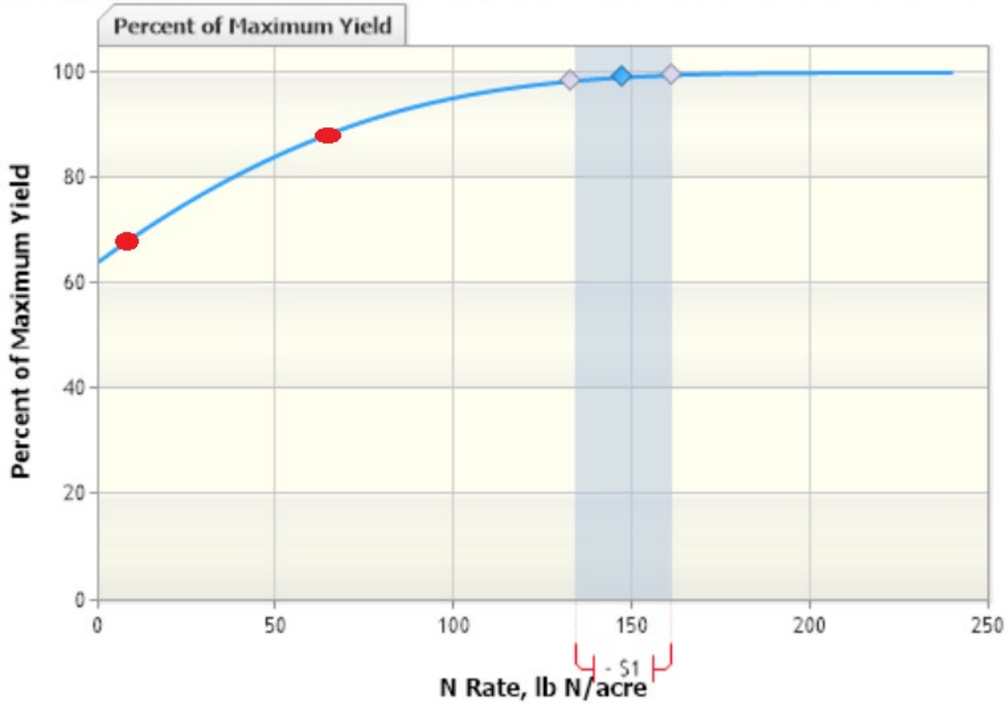
Manure Timing



In the shaded areas, the soil produces nitrate, but there is no crop to use it. As a result, some nitrate is lost to waterways.

Timing

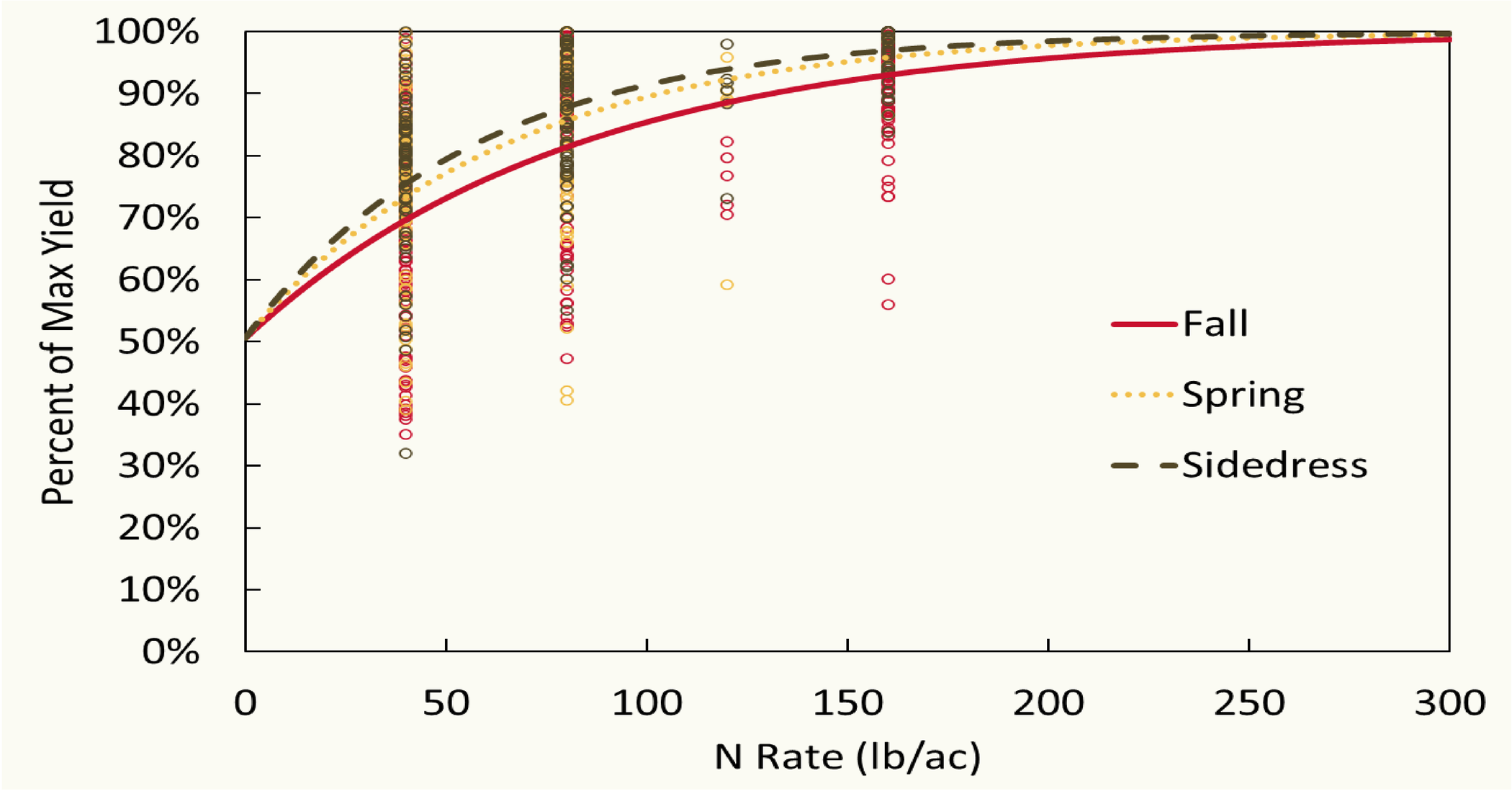

Corn Yield (bu/acre)
250
200
150
100
50
0
c
c
b
a
EFM 150NT
EFM 150NT + R
LFM 150NT
SPRING UAN150


Percent of Maximum Yield
Percent of Maximum Yield
100
80
60
40
20
0
0
50
100
150
200
250
S1
N Rate, lb N/acre

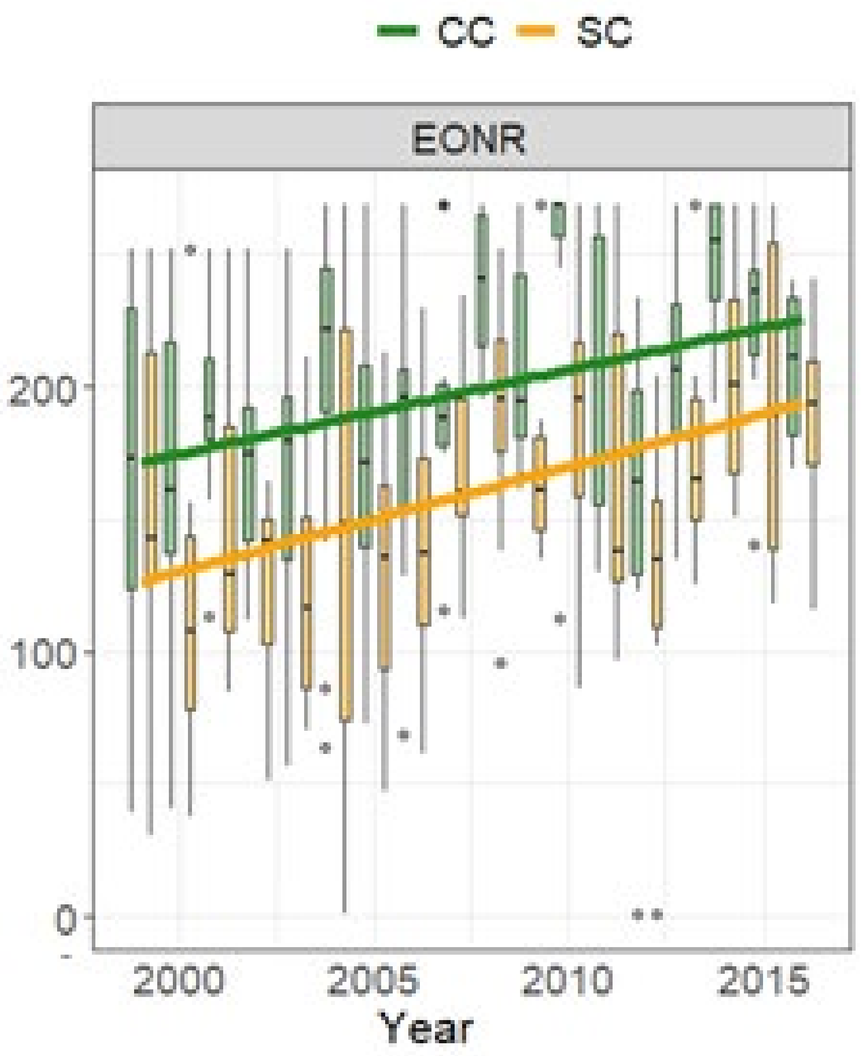
Water Quality Impact

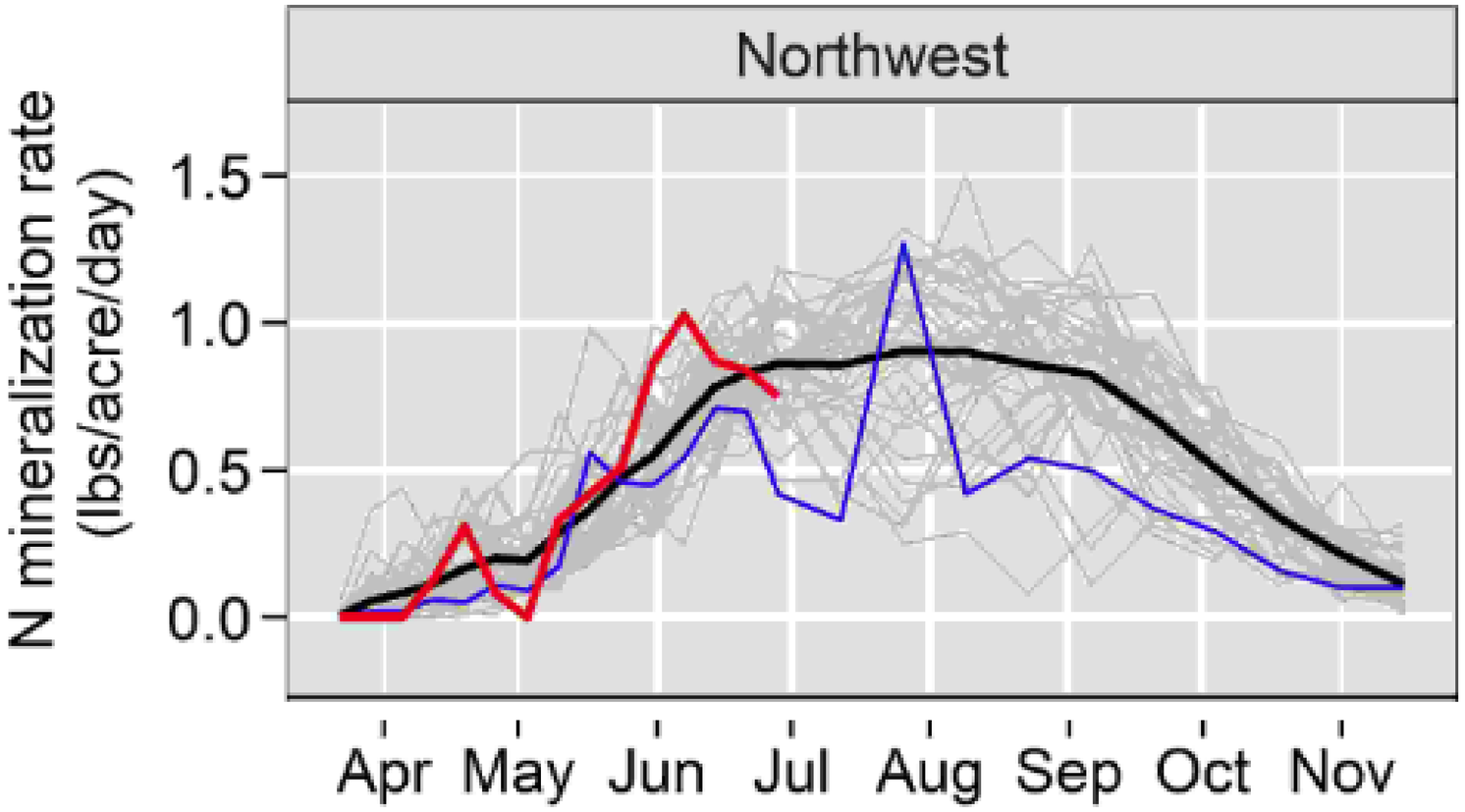
Nitrate-N concentrations in drainage water (mg/L)					
Crop	**Year**	**EFM150NT**	**EFM150NT+R**	**LFM150NT**	**SPRING UAN150**
Corn	2016	20.5a	11.3c	15.7b	12.0c
	2017	27.2a	12.0c	20.1b	13.2a
	2018	12.3a	11.9a	11.2a	10.5a
	Avg	**20.0a**	**11.7c**	**15.6b**	**11.9bc**
Soybean	2016	10.9a	6.7b	12.0a	11.4a
	2017	9.5ab	4.9c	8.7b	12.6a
	2018	7.2bc	5.6c	8.3ab	9.5a
	Avg	**9.2b**	**5.7a**	**9.7b**	**11.2b**

Timing

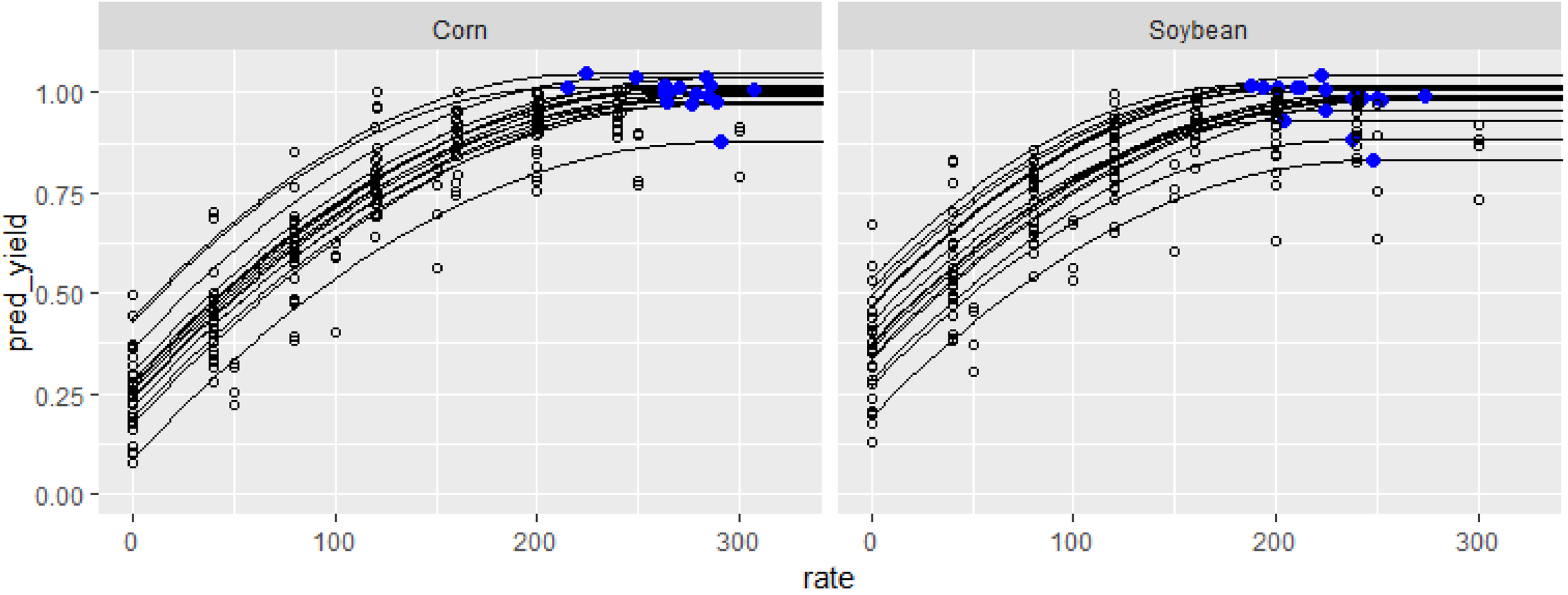

100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Max Yield
0
50
100
150
200
250
300
N Rate (lb/ac)
Fall
Spring
Sidedress

Variation in Nitrogen Need

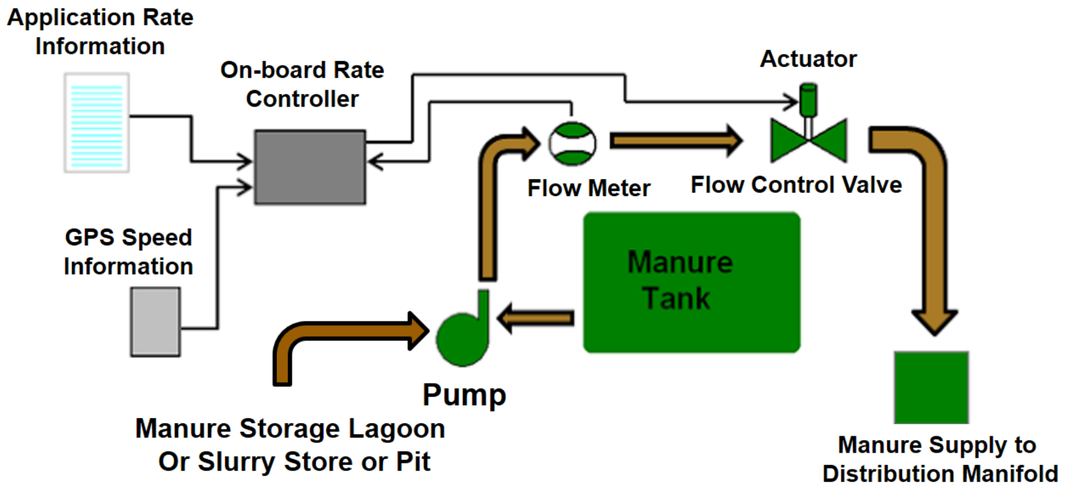




Variation in Nitrogen Need



Ability to Hit Rate



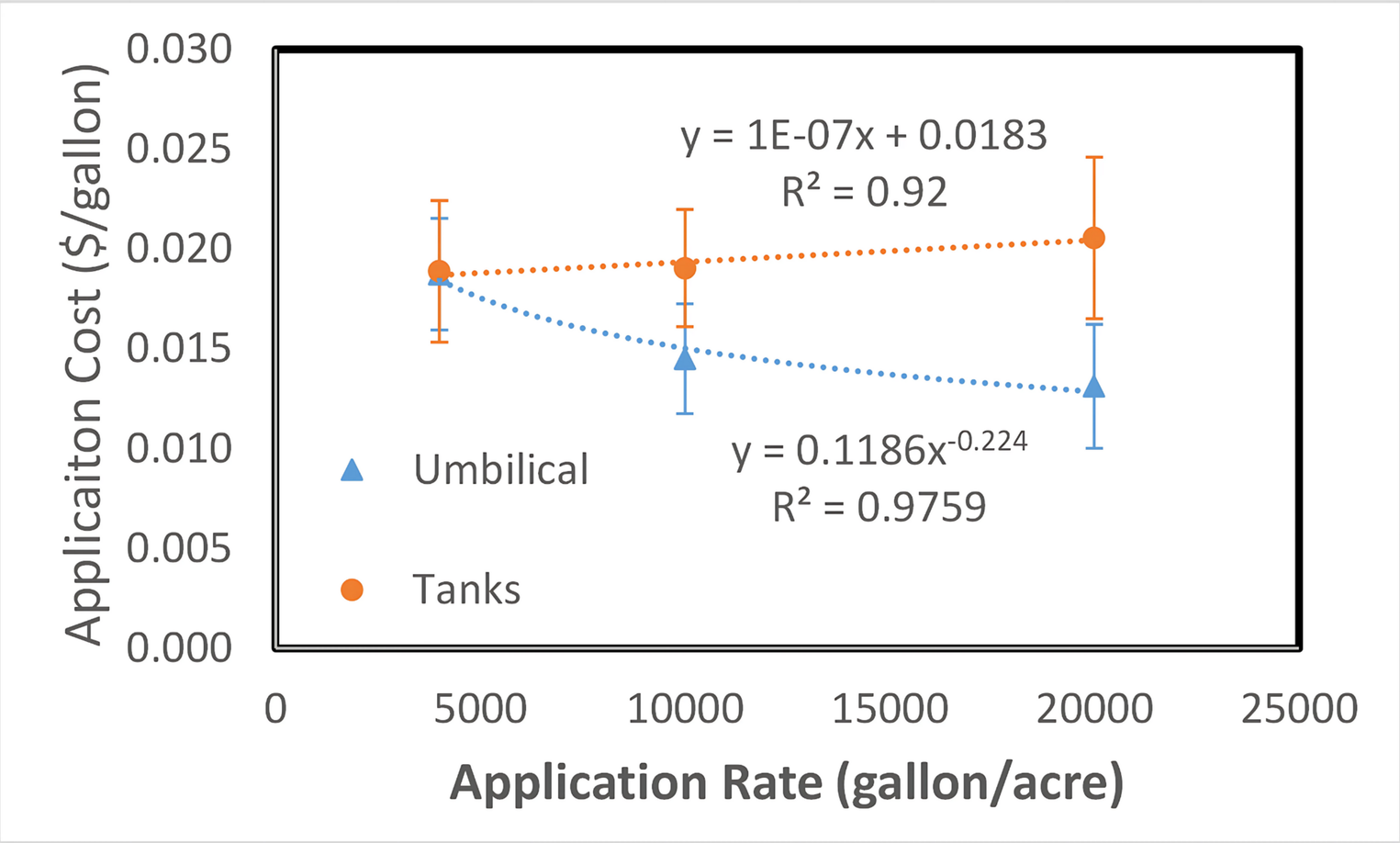
- But what if I ask for 3000 gallons an acre, or 2000 gallons an acre?

Comparison of target manure volume based on pre-application sample and actual volume applied.[a]

Year	Target Volume (average) L	Target Volume (average) gal	Applied Volume (average) L	Applied Volume (average) gal	Change (%)	Weighted-Average CV for Applied Volume
2007	10,893	2878	11,291	2983	3.6	3.8
2008	12,067	3188	12,680	3350	5.1	4.1
2009	13,516	3571	13,501	3567	-0.1	1.5
2010	12,790	3379	13,176	3481	3.0	3.5
2011	12,237	3233	13,391	3538	9.4	2.8
2012	14,061	3715	13,713	3623	-2.5	2.8
2013	12,472	3295	13,372	3533	7.2	2.0
2014	11,276	2979	12,589	3326	11.6	4.7
Avg.	12,415	3280	12,964	3425	4.7	3.2

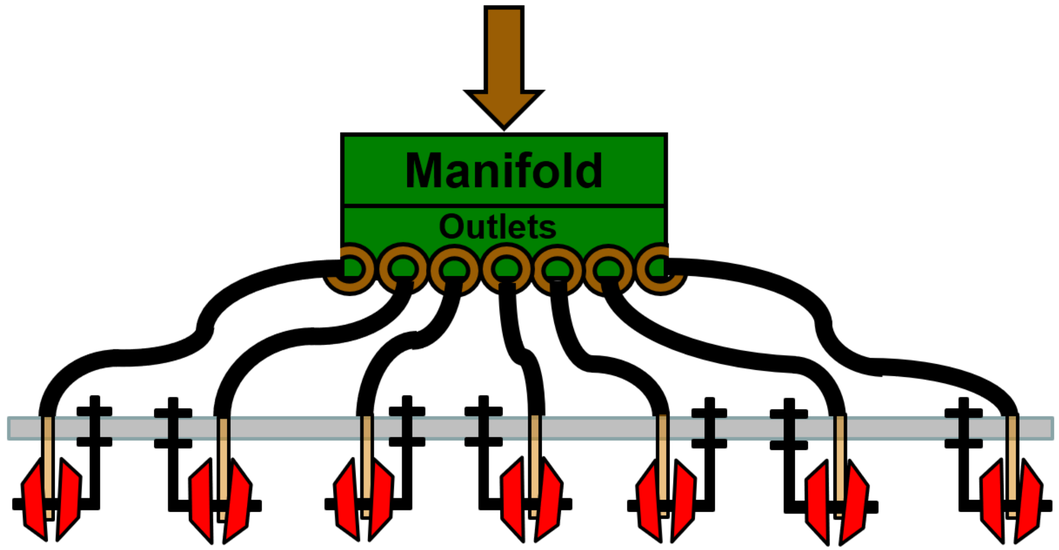
[a] Target and applied volumes are based on the 18-plot average of three different target rates.

Ability to Hit Rate

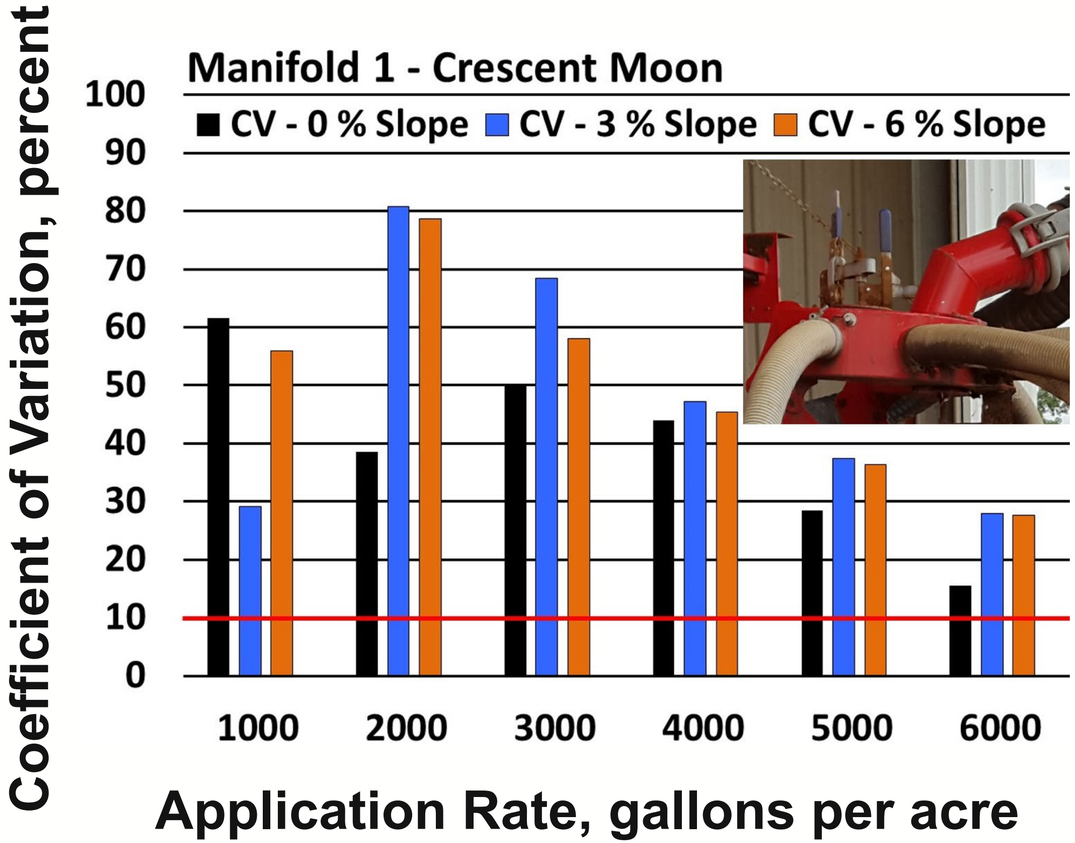


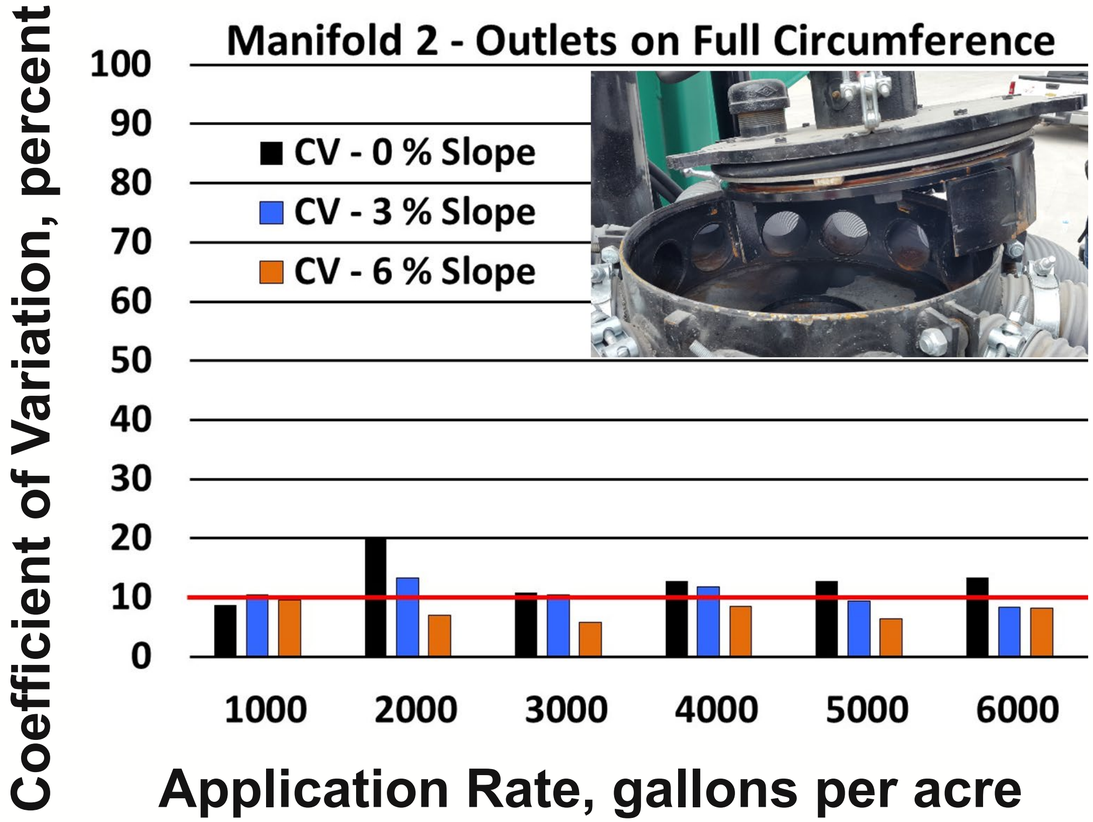
- 2000 gallon/acre ($0.0216/gallon)
- 3000 gallon/acre ($0.0197/gallon)
- 4000 gallon/acre ($0.0185 /gallon)

Uniformity of Application



Manifold Performance





But what do we do with variability?

Application characteristic

Manure Type	Method	N Content	Availability %	Volatilization %	Rate %	Uniformity %	Timing %
Liquid Swine	Inject	6.01 (0.33)	95 (5)	98 (1)	7 (4)	15 (5)	42 (26)
Liquid Swine	Broadcast	6.01 (0.33)	95 (5)	82.5 (7.5)	5 (2)	5 (5)	42 (26)
Liquid Dairy	Inject	3.01 (0.36)	40 (10)	98 (1)	5 (1)	10 (5)	42 (26)
Liquid Dairy	Broadcast	3.01 (0.36)	40 (10)	82.5 (7.5)	5 (1)	5 (5)	42 (26)
Solid Layer	Incorporate	35 (5)	55 (5)	97 (2)	10 (5)	15 (5)	42 (26)
Solid Layer	Broadcast	35 (5)	55 (5)	77.5 (7.5)	10 (5)	15 (5)	42 (26)
Solid Beef	Incorporate	12 (3)	40 (10)	97 (2)	15 (7)	20 (5)	42 (26)
Solid Beef	Broadcast	12 (3)	40 (10)	77.5 (7.5)	15 (7)	20 (5)	42 (26)

Estimating Yield and Economic Impact

Methods

Develop a Stochastic N Supply Model calculated the overall mass of N available.
The mass of nitrogen applied and available to support crop growth was calculated as:

$$M_N = V_K C_N A_N Q_N - L_N \qquad \text{(Eq. 1)}$$

Where
M_N is the mass of plant available nitrogen supplied to support crop growth (kg N/ha).
V_K is the volume of manure applied through each knife (m^3/ha)
C_N is the concentration of total nitrogen in the manure (kg N/m^3)
A_N is the percent of total nitrogen that becomes plant available in the growing season (kg N/kg N)
Q_N is the percent of total nitrogen that doesn't volatilize (kg N/kg N)
L_N is the loss in mass of nitrogen supplied as compared to spring application (kg N/ha)

The knife application rate was calculated as:

$$V_K = C_K V_T \qquad \text{(Eq. 2)}$$

Where
V_T is the volume of manure applied (m^3/ha), and
C_K is the coefficient of flow for that knife (m^3/m^3)

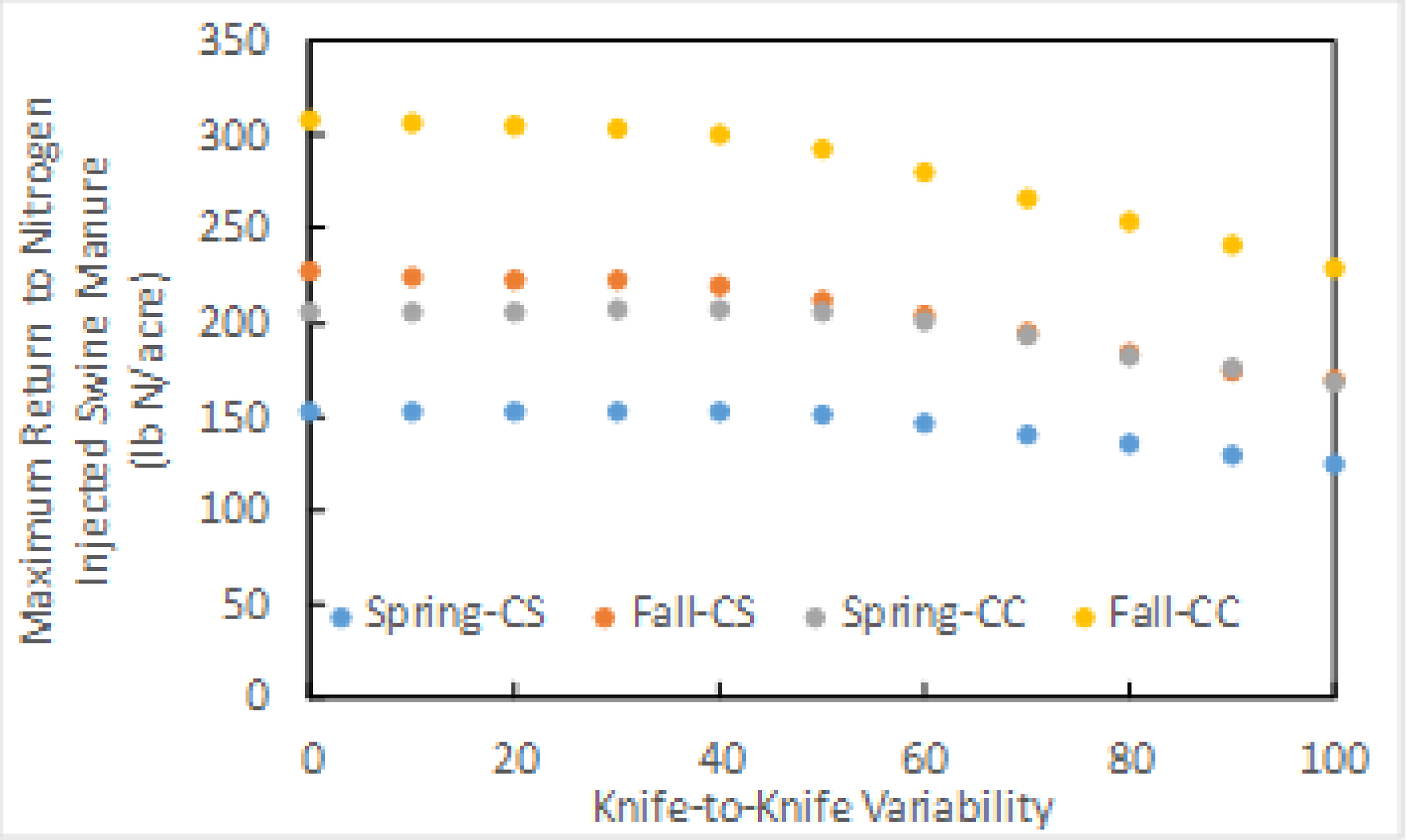
The mass of nitrogen lost between fall and spring application (L_N) was calculated as:

$$L_N = V_K C_N A_N Q_N (1 - N_F) \qquad \text{(Eq. 3)}$$

Yield estimated based of MRTN curve:

$$\%Yield = 100\left(1 - exp(-0.0172(x + 57.6))\right) \qquad \text{(Eq. 4)}$$

Estimating Yield and Economic Impact



Contact Information

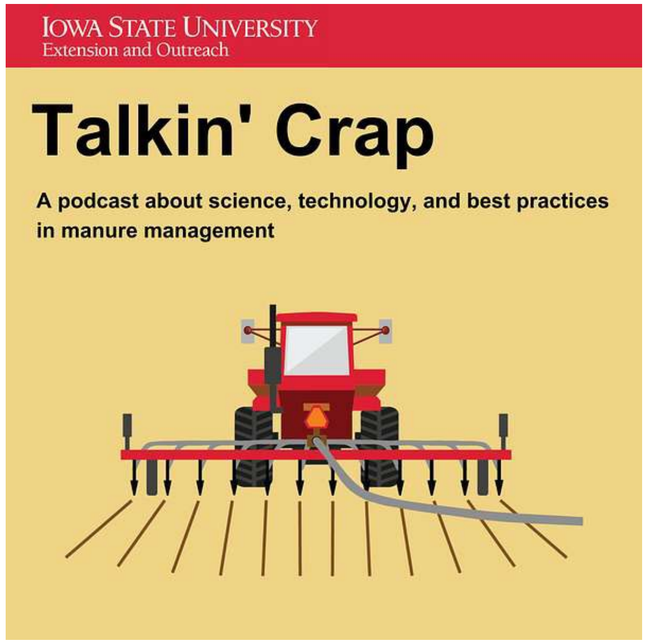
Daniel Andersen

Associate Professor

dsa@iastate.edu

515.294.4210

www.abe.iastate.edu



DrManure

Iowa State Manure and Nutrient Management Lab