PASTURE FERTILITY AND THE NUTRIENT CYCLE

LEARNING TO WORK WITH THE UNDERSTANDING OF YOUR SOIL

Fertilizing Pastures

THE ROLE OF SOIL TESTING IN PASTURE MANAGEMENT

- Soil test levels ???

- Forage selection **Will it grow??**

- Identifying limiting factors ??ʔ

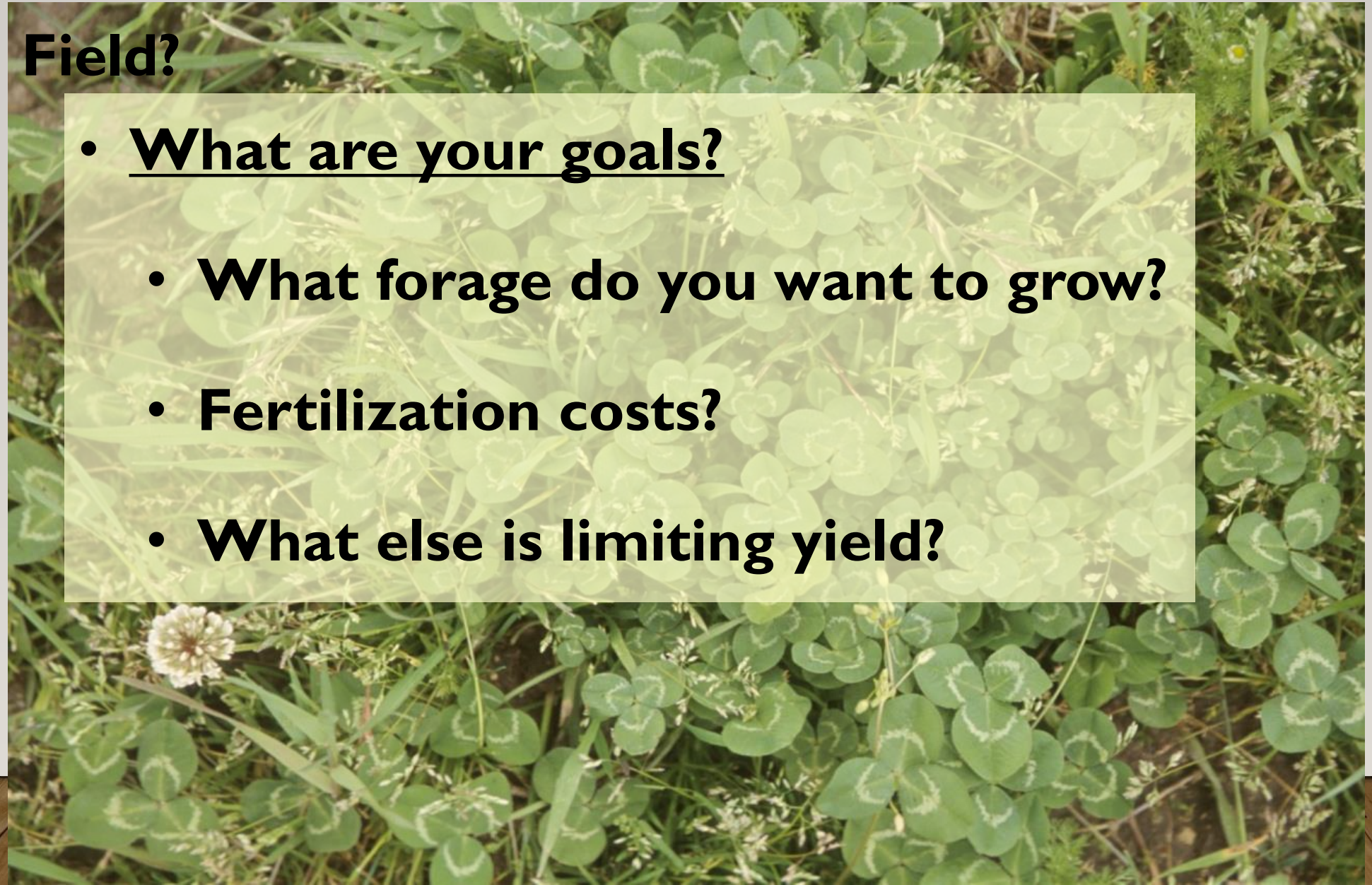
Should I Fertilize?

- **Fertilizing on a budget**
  - Target very low and low testing soils
  - Lime first
  - Low rates (20 lb. P_2O_5/acre) on fescue reduces grass tetany
  - Manure can be a excellent fertilizer

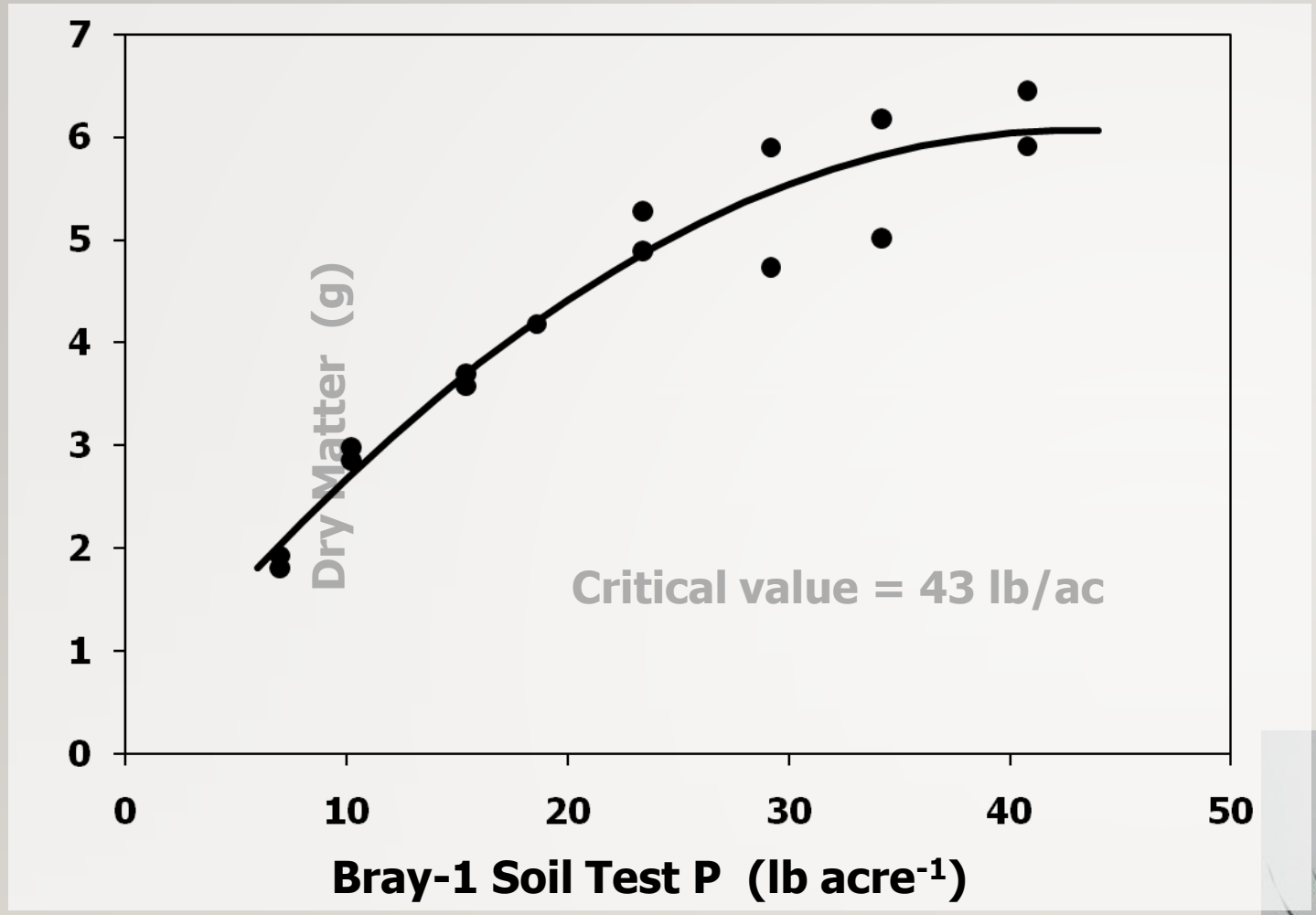
BASIC FUNCTIONS OF A SOIL TEST

- Provide a starting point for developing fertilizer and lime recommendation program
- Monitor the changes in soil nutrient status, and soil reaction (pH) to keep the fertilizer and liming on track

What is Optimum Soil Test Levels for Your Field?



- **<u>What are your goals?</u>**
  - **What forage do you want to grow?**
  - **Fertilization costs?**
  - **What else is limiting yield?**

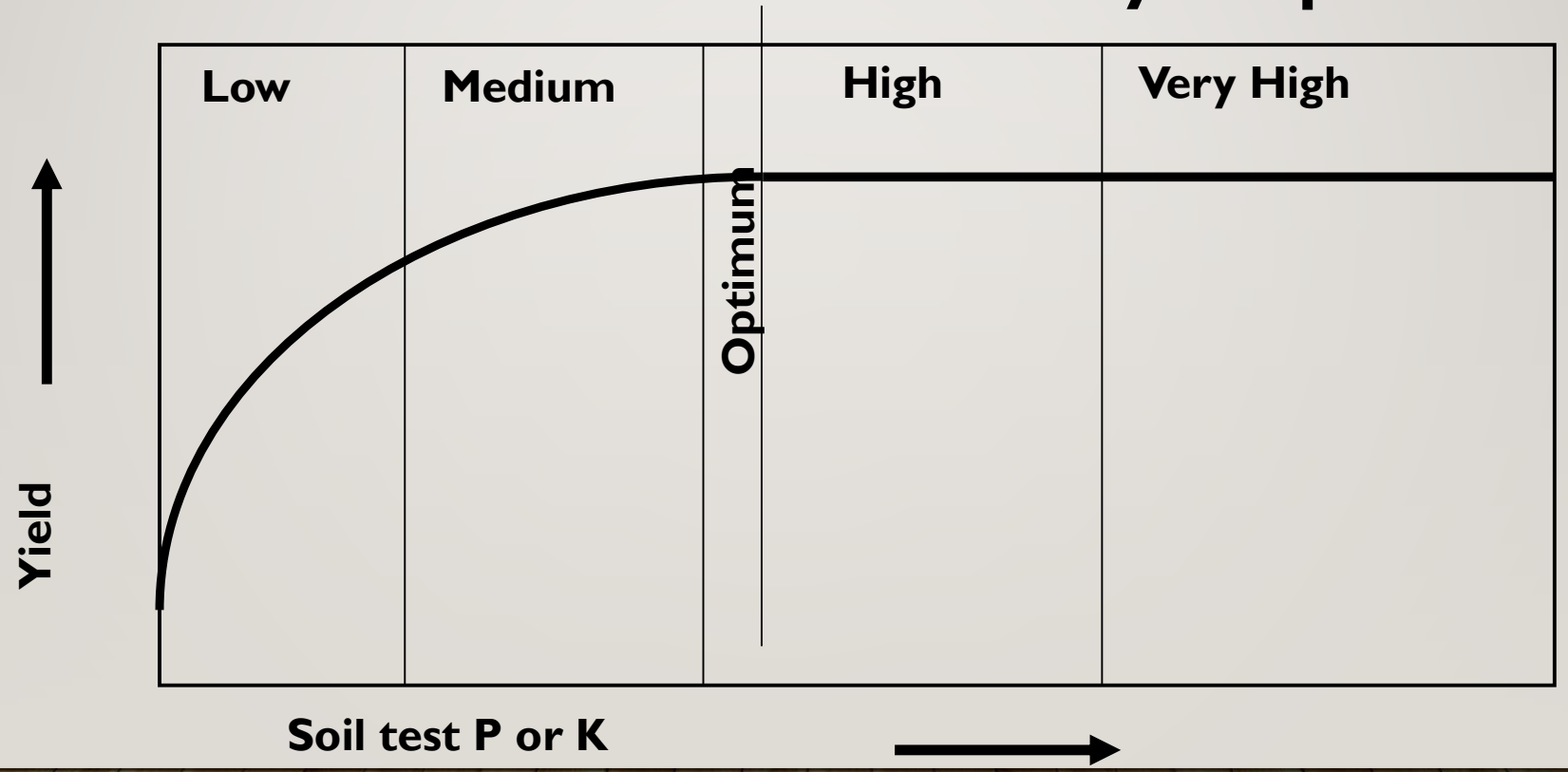


What is Optimum for Your Field?

CRELDON SOIL

TRADITIONAL SOIL TEST OBJECTIVE

Optimize soil test level to maximize yield potential.



Interpreting Soil Tests

- **Low**
  - Yield loss likely
  - Forage quality reduced
- **Medium**
  - Yield loss possible
  - Improved persistence of desirable species
  - Improved forage quality
- **High**
  - Benefits from fertilization unlikely
- **Very High**
  - Field can be cropped for an extended period with no benefits from fertilization.

Soil Test Information			Rating			
			Very Low	Low	Medium	High
pH_s	(salt pH)	5.5	********	********	**	
Phosphorus	(P)	28 lbs/A	********	********	*****	
Potassium	(K)	205 lbs/A	********	********	*****	

CHARACTERISTICS OF LOW FERTILITY SOILS

- **Reduced yield**
- **Reduced persistence of desirable species**
- **Reduced forage quality**
- **Dependent on fertilizer N (legumes do not persist in low fertility soils).**

Soil Test Level for Persistence

Your level of soil fertility must match or exceed the needs of your selected forage.

HOW MANY ELEMENTS DO WE USUALLY WORK WITH IN A BALANCED SOIL? (17)

From Air & Water	Macronutrient	Micronutrient
• Carbon	Nitrogen	Iron
• Hydrogen	Phosphorus	Manganese
• Oxygen	Potassium	Boron
	Calcium	Molybdenum
	Magnesium	Copper
	Sulfur	Zinc
		Nickel
		Chlorine
		Cobalt

NITROGEN IS ESSENTIAL FOR:

- Photosynthesis
  - Integral part of chlorophyll
- Amino acids, nucleic acids, and coenzymes
- Protein
  - Building block of plant proteins
- Carbohydrate Utilization
- Stimulates root growth
- Stimulates nutrient uptake

Nutrient that is most often deficient in soils

PHOSPHORUS IS ESSENTIAL FOR:

- 1. Essential for plant growth
- 2. Plays a role in photosynthesis, respiration, energy storage and transfer, and other processes.
- 3. Promotes early root formation and growth
- 4. Vital in seed formation
- 5. Strengthens structural tissue – prevents lodging
- 6. Improves winter hardiness
- 7. Improves forage crop quality
- 8. Increases water use efficiency- reduces water stress
- 9. Can boost yield levels and reduce grain moisture levels
- 10. Increases uptake of Mg – prevents grass tetany
- 11. Regulates protein synthesis
- 12. Development of new tissue
- 13. Hastens maturing
- 14. Stimulates tillering

P MOVEMENT:

- It has been estimated that Phosphorus placed ¼ inch away from a plant root will never move close enough to be taken up by the root.
- Phosphorus just does not move very quickly in the soil…..

- A grower can expect to get 20-30% efficiency from water soluble Phosphorus fertilizer the first year after application. (This is why yearly application are required)
- Most crops can't get enough Phosphorus
- Of all the soil test I have seen so far this is the ***number one*** element most often found to be in short supply……

ROLES OF POTASSIUM:

- Essential in photosynthesis, respiration and protein synthesis.
- Important in translocation of heavy metals (Fe)
- Helps plant overcome effects of disease/Insects
- Important in fruit formation
- Improves winter hardiness
- Important in osmotic regulation in plants
- Important in carbohydrate breakdown
- Reduces lodging
- Increases efficient water use and reduces drought stress
- Important in ionic balance

CEC RANGES

Soil Textural Classes	CEC (in meq/100g)
Sand	2 – 5
Sandy Loam	5 – 12
Loams	10 – 18
Silt and Silty Clay Loams	15 – 30
Clay and Clay Loams	25 – 40

Types of clays can play a role in the management of a soil

Most fertilizer and liming recommendations are based on CEC

RAISING CEC

- Improving your Organic matter content may improve your CEC

PH GOVERNS PRODUCTIVITY

- 1. Nutrient Availability
    - Extremes in pH cause elements to bind with non-nutrient elements, leaving them in a form that plants can not take up.
- 2. Strong acidic soils have low amounts of CEC occupied by K, Mg, and Ca.
- 3. Affects pesticides
- 4. Affects the population and activity microbial activity in the soil
- 5. Activity of nitrogen-fixing bacteria is impaired

WEEDS THAT ARE INDICATORS OF ACID SOILS AND OR POOR FERTILITY

- Broomsedge
- Red Sorrel
- Briers
- Sumac
- Purple top
- Fescue
- Ticklegrass
- Witchgrass

FACTORS CAUSING PH TO CHANGE:

- 1. Depletion of Ca by erosion, leaching or plant use.
- 2. Leaching
- 3. Absorption of bases by plants
- 4. Chemical fertilizers
- 5. Tillage practices
- 6. Acid rain
- 7. Waste and sewage sludge
- 8. Irrigation
- 9. Excessive applications of nitrogen (unbalanced soil fertility)

FACTORS INFLUENCING FREQUENCY OF LIMING:

- 1. Soil Texture
- 2. Rate of N fertilization
- 3. Rate of crop removal
- 4. Amount of lime applied
- 5. pH range desired

WHEN SHOULD LIME BE APPLIED?

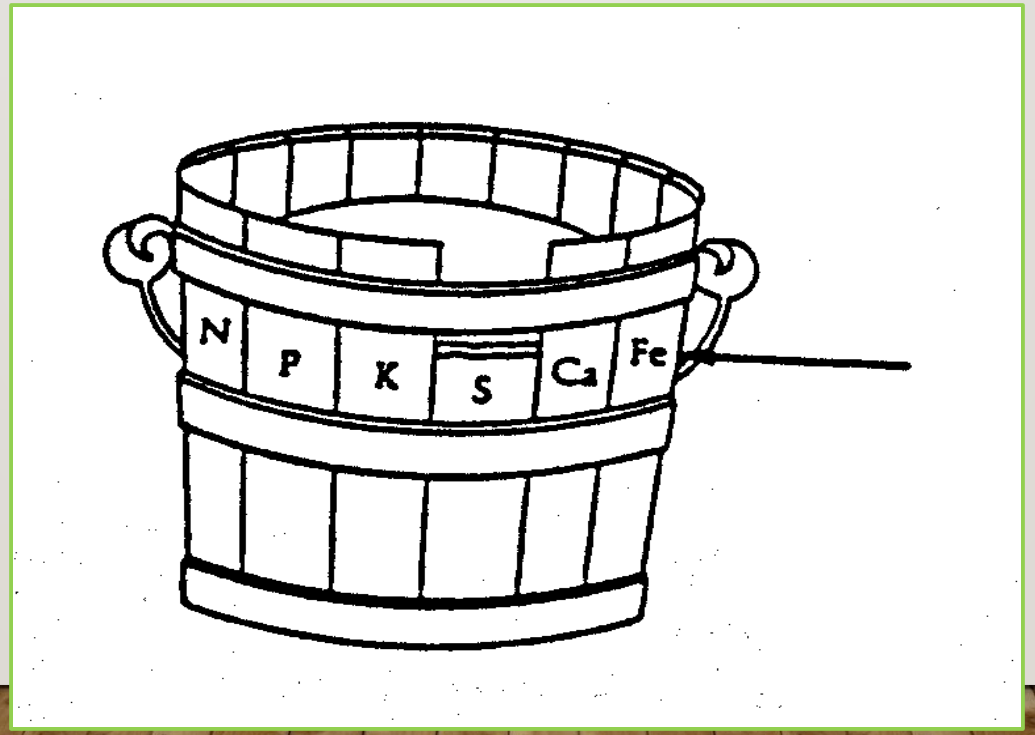
- Soil test for lime need every 3 years.
- 3-6 months before planting legumes
  - Best results occur when there is close contact
- Anytime of year
- 3-6 months before planting legumes

ALTERING PH LEVELS WITH LIME

- To Lower pH add:
  - Elemental sulfur
    - Biological Reaction: Takes 3-6 months for results
  - Iron Sulfate ($FeSO_4$)
    - Chemical Reaction: Quick Results
  - Add Acids – USE WITH CAUTION
    - $H2SO4 \text{ --------> } 2\ H^+ + SO_4^{-2}$
- To Raise pH add:
  - Limestone prior to planting
    - Biological Reaction: Takes 3-6 months for results

MOST LIMITING NUTRIENT

- This determines the growth and reproduction of plants.



University Extension

Soil Test

UNIVERSITY OF MISSOURI Extension

Soil Testing Laboratory
23 Mumford Hall, MU
Columbia, MO 65211
Phone: (573) 882-0623

or

Soil Testing Laboratory
P.O. Box 160
Portageville, MO 63873
Phone: (573)379-5431

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http://www.soiltest.psu.missouri.edu/

Serial no. S80751-1	**Lab no. D1503136**
County Dallas	Region 7
Submitted 4/10/2015	Processed 4/14/2015

Soil sample submitted by: Firm Number: Outlet:

SOIL TEST INFORMATION			RATING					
			Very Low	Low	Medium	High	Very High	Excess
pH_s	(salt pH)	5.4	**********					
Phosphorus	(P)	5 lbs/A	****					
Potassium	(K)	192 lbs/A	**********					
Calcium	(Ca)	3730 lbs/A	**********					
Magnesium	(Mg)	565 lbs/A	**********					
Sulfur	(SO_4-S)	ppm						
Zinc	(Zn)	ppm						
Manganese	(Mn)	ppm						
Iron	(Fe)	ppm						
Copper	(Cu)	ppm						

Organic matter	4.4 %	Neutralizable acidity	2.5 meq/100g	Cation Exch. Capacity	14.4 meq/100g		
PH in water		Electrical Conductivity	Mmho/cm	Sodium (Na)	lbs/A		
Nitrate (NO_3-N) Topsoil	ppm	Subsoil	ppm	Sampling Depth	Top Inches	Subsoil	Inches

NUTRIENT REQUIREMENTS

Cropping options	Yield goal	Pounds per acre					
		N	P_2O_5	K_2O	Zn	S	

LIMESTONE SUGGESTIONS

Soil Test

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or

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Portageville, MO 63873
Phone: (573)379-5431

http://www.soiltest.psu.missouri.edu/

Serial no. S80745-3	**Lab no. D1501963**
County Dallas	Region 7
Submitted 3/9/2015	Processed 3/13/2015

Soil sample submitted by: Firm Number: Outlet:

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SOIL TEST INFORMATION		RATING					
		Very Low	Low	Medium	High	Very High	Excess
pH_s (salt pH)	6.3	**********	**********	**********			
Phosphorus (P)	35 lbs/A	**********	**********	******			
Potassium (K)	288 lbs/A	**********	**********	**********	**********		
Calcium (Ca)	4410 lbs/A	**********	**********	**********	**********	**********	
Magnesium (Mg)	414 lbs/A	**********	**********	**********	**********	**	
Sulfur (SO_4-S)	ppm						
Zinc (Zn)	ppm						
Manganese (Mn)	ppm						
Iron (Fe)	ppm						
Copper (Cu)	ppm						

Organic matter	3.8 %	Neutralizable acidity	1.0 meq/100g	Cation Exch. Capacity	14.1 meq/100g
PH in water		Electrical Conductivity	Mmho/cm	Sodium (Na)	lbs/A

Nitrate (NO_3-N) Topsoil	ppm	Subsoil ppm	Sampling Depth	Top Inches	Subsoil Inches

NUTRIENT REQUIREMENTS

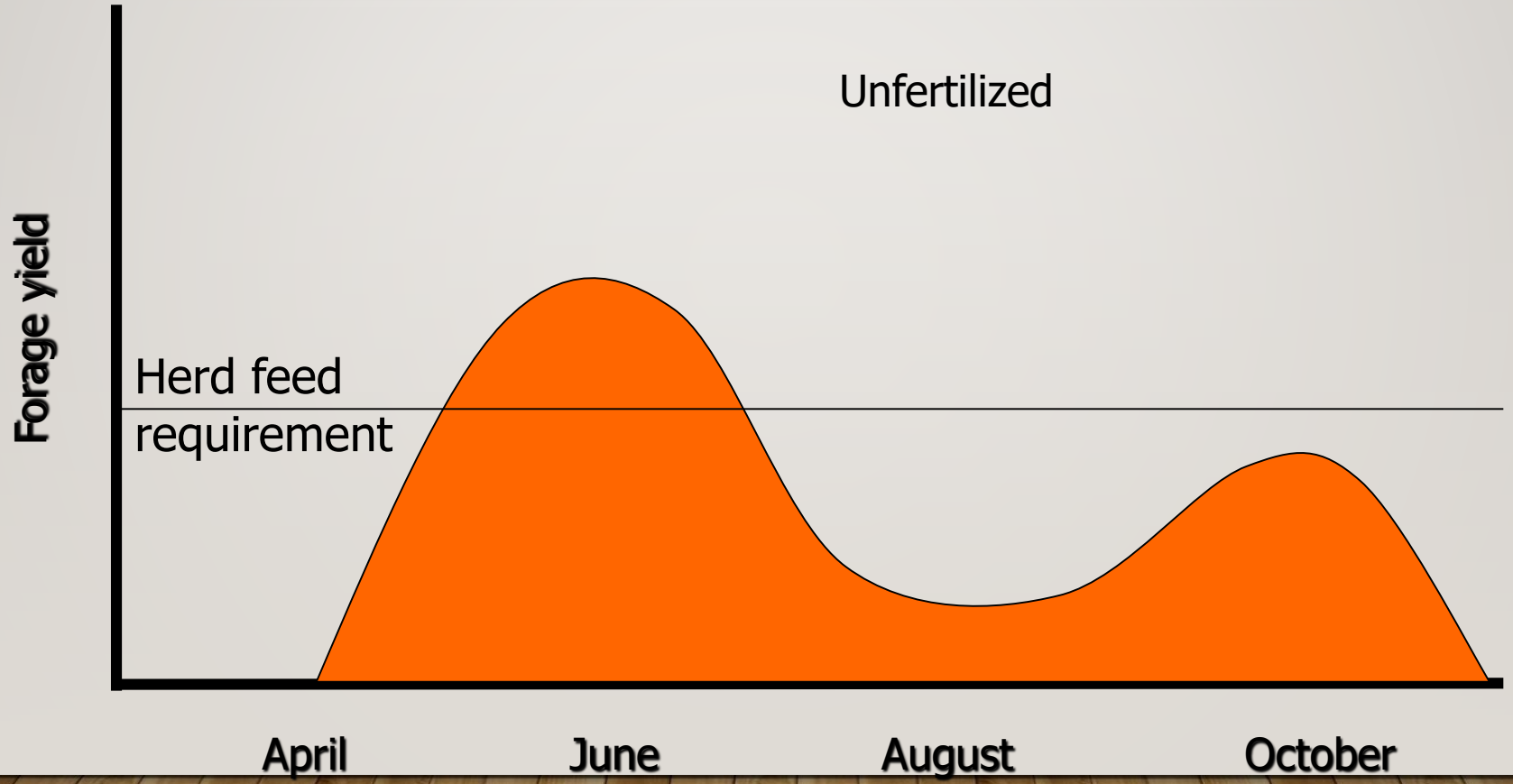
LIMESTONE

MAINTAINING SOIL FERTILITY

1 ton of decent hay removes:

- 40 lb. nitrogen
- 5.3 lb. P (12 lb. P_2O_5)
- 40 lb. K (50 lb. K_2O)

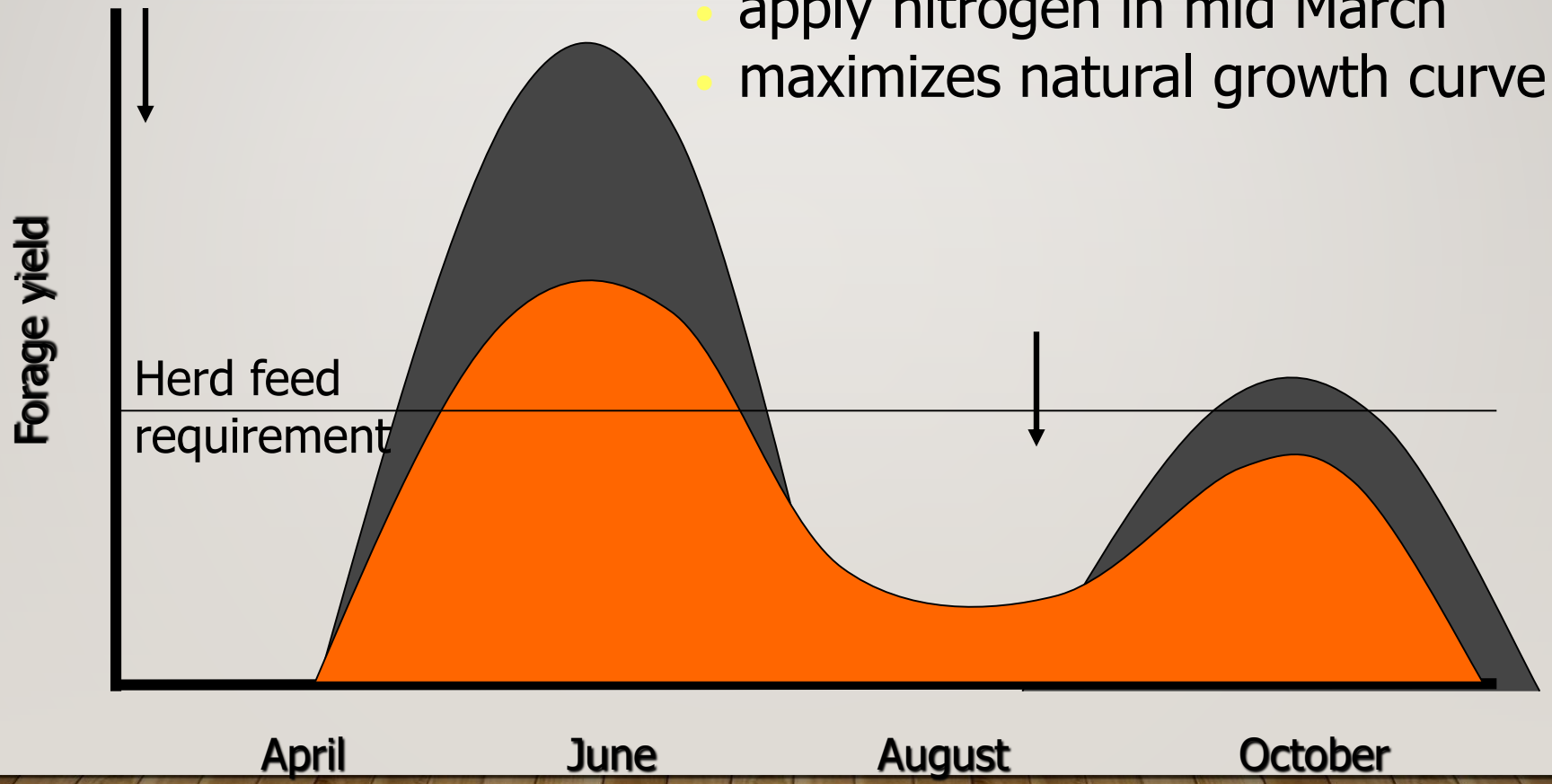
NITROGEN FOR TALL FESCUE



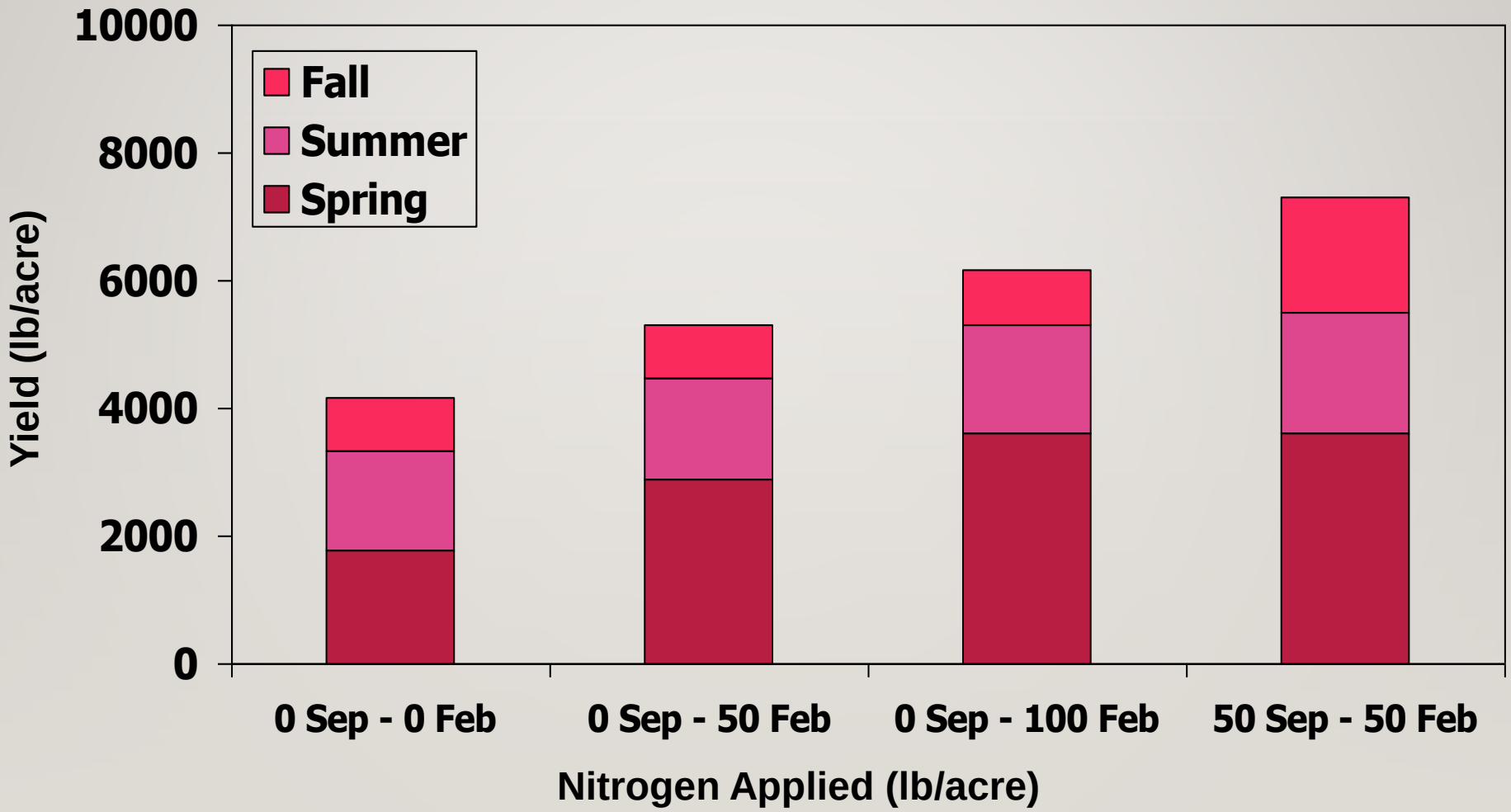
NITROGEN FOR TALL FESCUE HAY

Traditional spring fertilization for Hay:

- apply nitrogen in mid March
- maximizes natural growth curve



FERTILIZATION OF TALL FESCUE



Georgia

Hoveland and Richardson, 1992

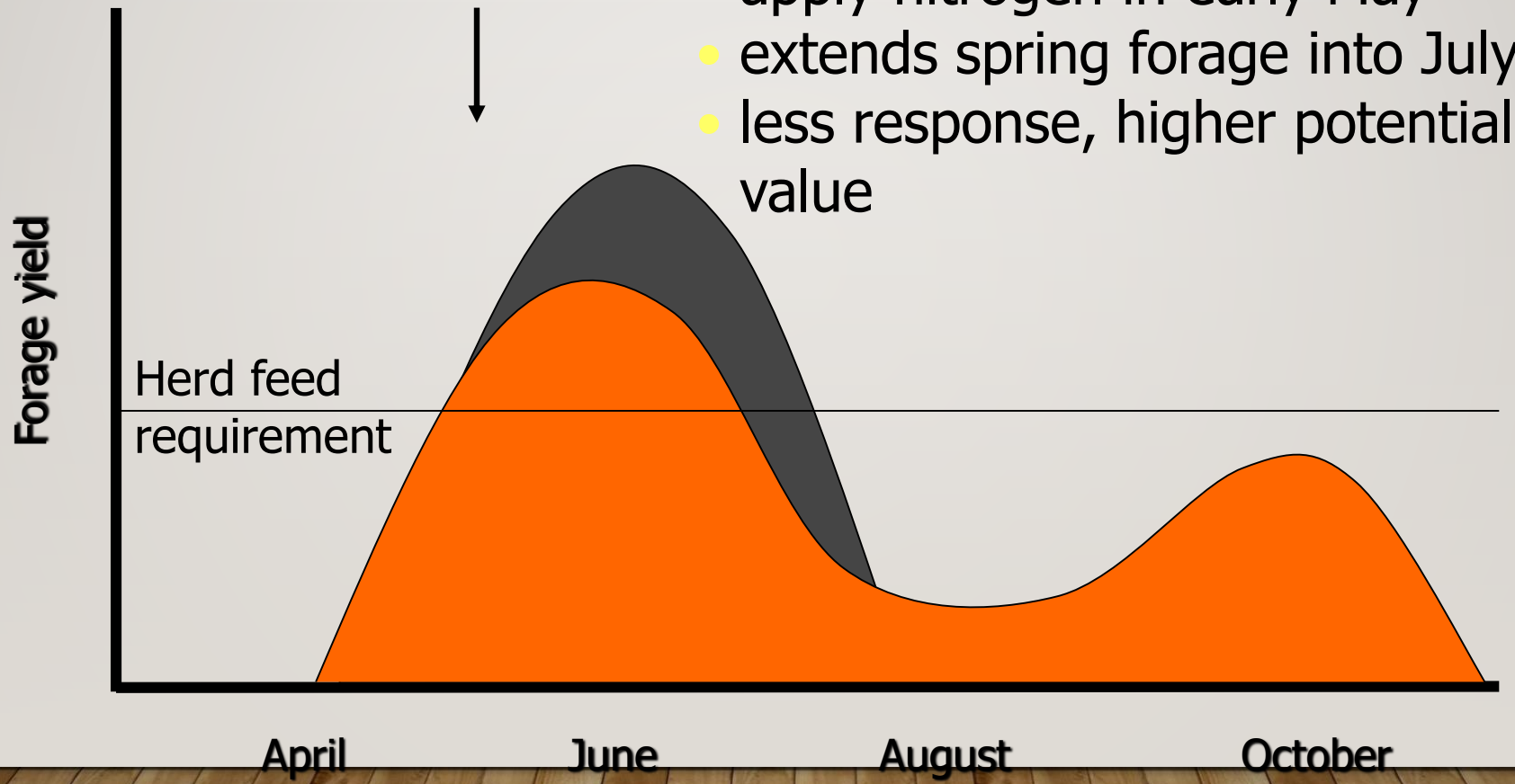
N FERTILIZER FOR TALL FESCUE HAY

- Spring application early near time plant starts growing.
  - High probability of response.
  - Harvest quality hay to make fertilizer pay.
- Fall application in mid August to promote fall growth.
  - Response depends on sufficient fall moisture
- Typical split: 60% – 40% with highest rate in the season that you most likely to utilize the forage.

NITROGEN FOR TALL FESCUE PASTURE

Spring fertilization for Pasture:

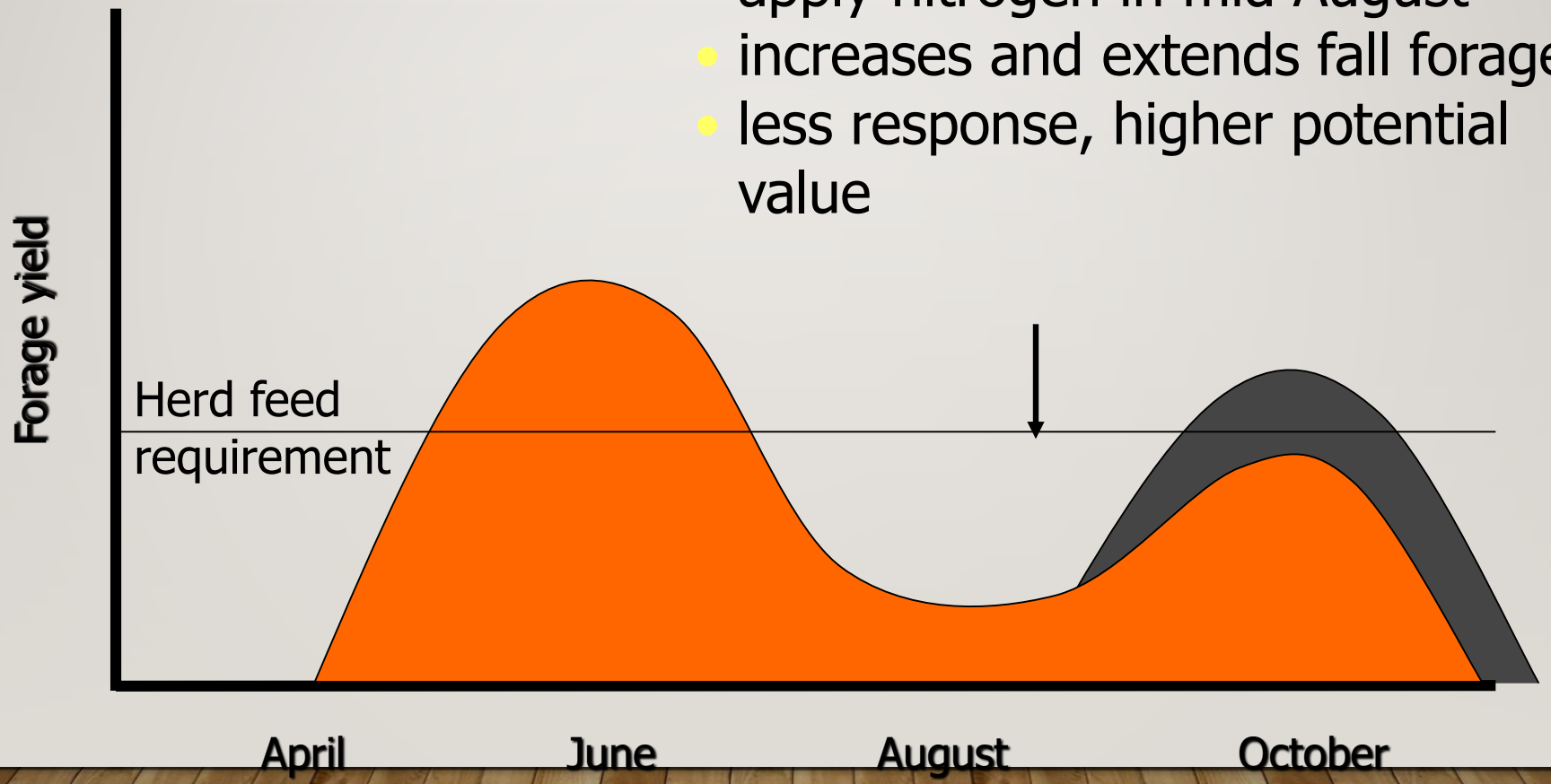
- apply nitrogen in early May
- extends spring forage into July
- less response, higher potential value



NITROGEN FOR TALL FESCUE PASTURE

Fall fertilization for Pasture:

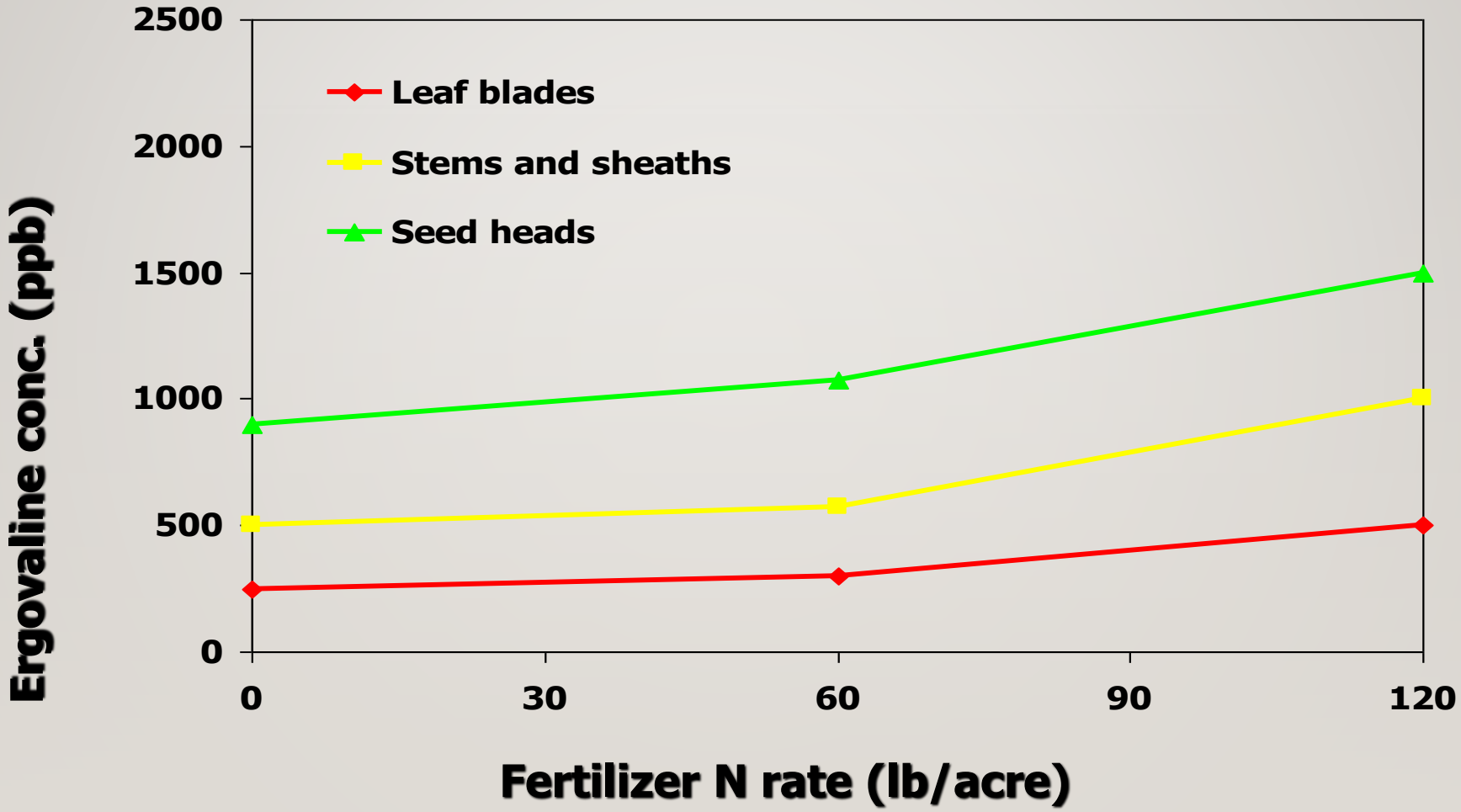
- apply nitrogen in mid August
- increases and extends fall forage
- less response, higher potential value



N FERTILIZER FOR TALL FESCUE PASTURE

- Spring application after early grazing (late April to early May) *if forage is needed*.
  - High probability of response.
  - Fertilization later than hay promotes more late spring growth
- Fall application in mid August to promote fall growth.
  - Response depends on sufficient fall moisture
  - Fall forage valuable in pasture systems

ERGOVALINE CONCENTRATION: TALL FESCUE



Columbia, MO

Rottinghaus et al., 1991

BENEFITS OF LEGUMES

- Provide N
- Increase forage quality
  - Less fescue = less endophyte
  - Legume forage quality $\geq$ fescue
- Better yield distribution

N_2 Fixation in Mixed Stands

Species	N_2 Fixed (lb./a)		Ndff
	Year 1	Older	(%)
Alfalfa	70 – 80	120 – 180	60 – 94
Birdsfoot trefoil	30 – 60	80 – 150	40 – 94
Red clover	10 – 90	40 – 330	40 – 96
White clover	1 - 100	20 – 300	37 – 100

(Ledgard and Steele, 1992; West and Mallarino, 1996)

NITROGEN FERTILIZER FOR TALL FESCUE/LEGUME MIX

- N fertilizer increases grass growth – hurts legume
  - N fertilized grass smothers legume
  - Without fertilizer N grass growth limited, legume thrives on N fixation
  - Few studies show N response when legume exceeds 25% of stand

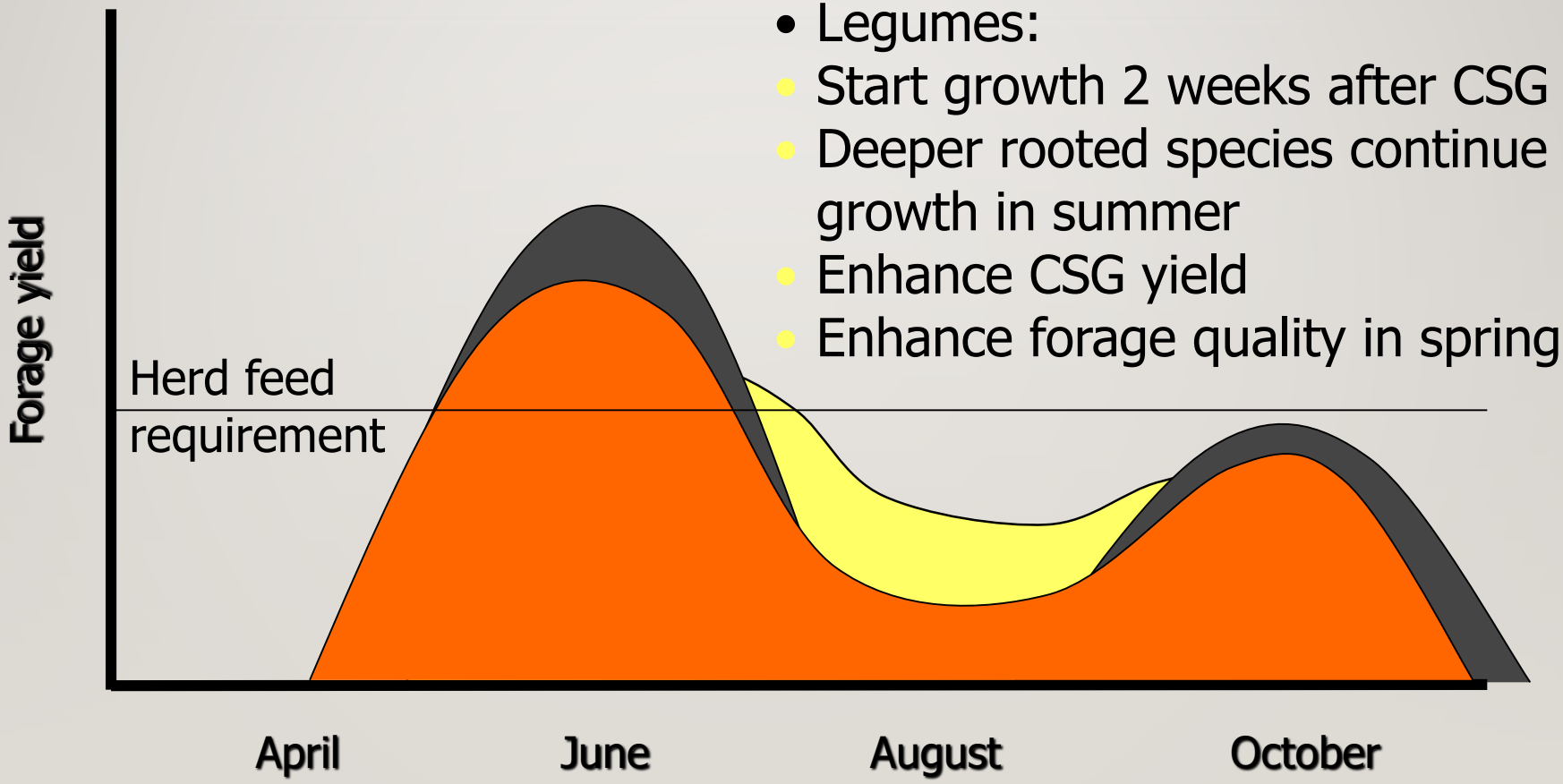
- If you use fertilizer N apply small amounts at times when legumes are dormant
  - Apply in early spring
  - Harvest or graze in a timely fashion.

Seeds should be inoculated to ensure fixation

Not inoculated

Inoculated

LEGUME/TALL FESCUE MIX



- Legumes:
  - Start growth 2 weeks after CSG
  - Deeper rooted species continue growth in summer
  - Enhance CSG yield
  - Enhance forage quality in spring

FERTILIZER PAYS WITH BETTER UTILIZATION

- Continuous grazed systems
  - 30% utilization of forage
  - Animals consume 600 lb. of every ton of forage
- Management intensive grazing
  - 50 to 70% utilization
  - Animals consume 1,000 to 1,400 lb. of every ton of forage

MAKING FERTILIZER PAY

- Fertilize when the plant has a capacity to respond
- Use fertilizer to increase forage at times when more forage is needed
- Maximize forage utilization
- High performing animals and high prices make it easier to pay for fertilizer
- It is easier to make money with cheap fertilizer
- You are only paying for fertility if it allows you to **buy less hay** or **sell more beef/milk**.

Should I Fertilize?

- Grass/legume mixture (30% or higher Legume)
  - pH 6 - 7
  - P and K at least medium
  - No fertilizer Needed

- Spring vs. Fall N
  - Only apply spring N if you are short on spring pasture or are haying
  - Apply 60-75 lb. N/acre in August for stockpiling

Maintaining Fertility
Pasture System

- **Low P and K removal**
  - **Monitor with soil testing**

- **Higher N losses therefore annual N inputs needed**
  - **Legumes**
  - **Fertilizers**
  - **Manure**

REVIEW OF KEY CONCEPTS

- Hay systems are removal systems.
- Pasture systems are recycling systems – but leak nitrogen.
- Not all nitrogen in manure is available to plants… but all the phosphorus and potassium is.

Feed as Fertilizer

NUTRIENT CONTENT

Poultry Litter	lbs/ton
Nitrogen	60
Phosphate	75
Potash	45

Fertilizer value (%)

3 - 4 - 2

Fertilizer value ($/ton)

2008	$135
2009	$80
2010	$68

2008 Fertilizer value based on $0.75/lb N, $1.10/lb phosphate, $0.55/lb potash.
2009 Fertilizer value based on $0.50/lb N, $0.40/lb phosphate, $0.70/lb potash.
2010 Fertilizer value based on $0.50/lb N, $0.30/lb phosphate, $0.60/lb potash.
Assumes manure N is 35% available and litter N is 60% available.

Decent Fescue Hay	lbs/ton
Nitrogen	55
Phosphate	16
Potash	49

Fertilizer value (%)

2.8 – 0.8 – 2.5

Fertilizer value ($/ton)

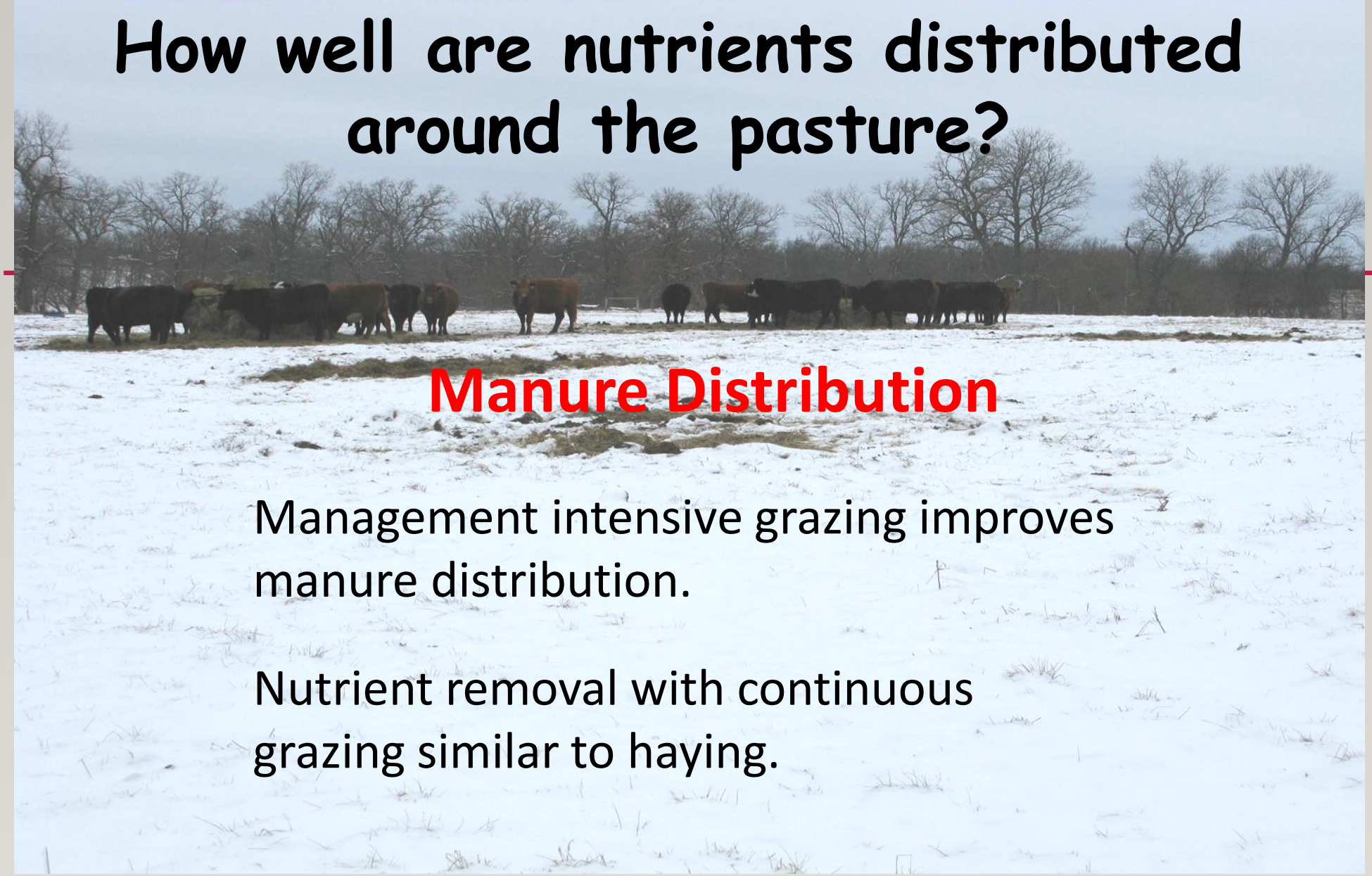
2008	$59
2009	$50
2010	$44

ONE COW ON HAY FOR 100 DAYS

	lbs	2008	2009	2010
		$	$	$
Available Nitrogen	29	21.65	14.50	14.50
Phosphate	24	26.40	9.60	7.20
Potash	73	40.24	51.10	43.80
		88.30	75.20	65.50

2008 Fertilizer value based on $0.75/lb N, $1.10/lb phosphate, $0.55/lb potash.
2009 Fertilizer value based on $0.50/lb N, $0.40/lb phosphate, $0.70/lb potash.
2010 Fertilizer value based on $0.50/lb N, $0.30/lb phosphate, $0.60/lb potash.
Assumes manure N is 35% available.

How well are nutrients distributed around the pasture?



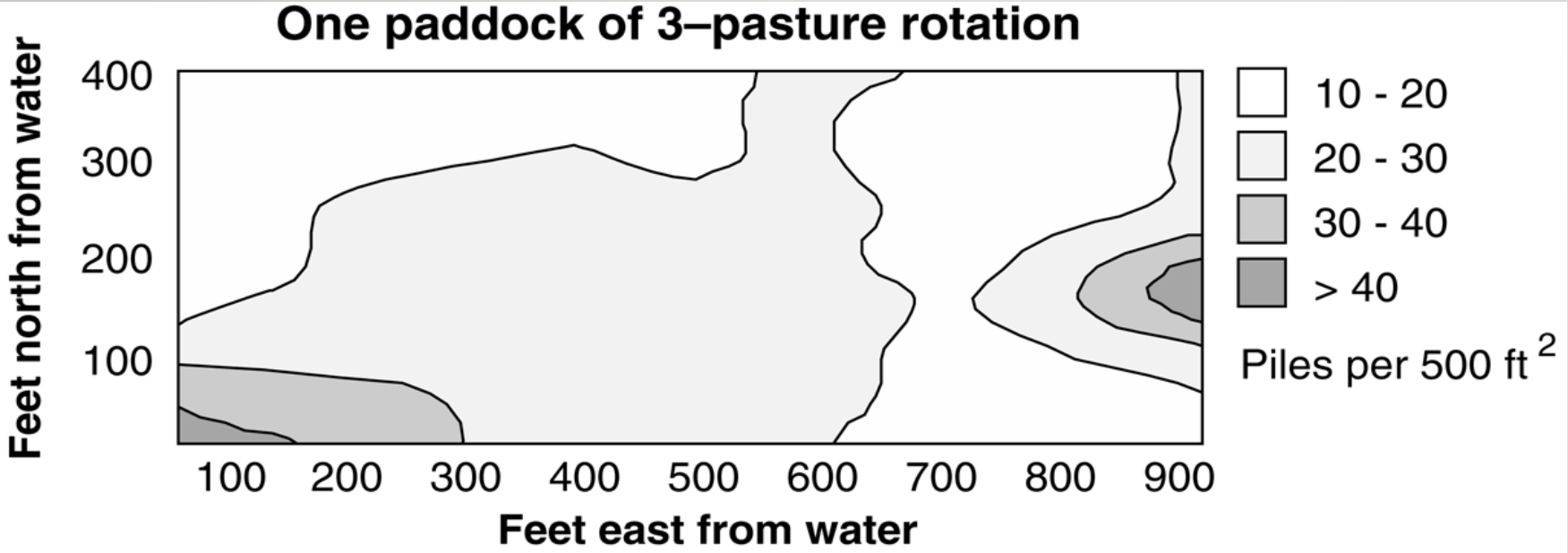
Manure Distribution

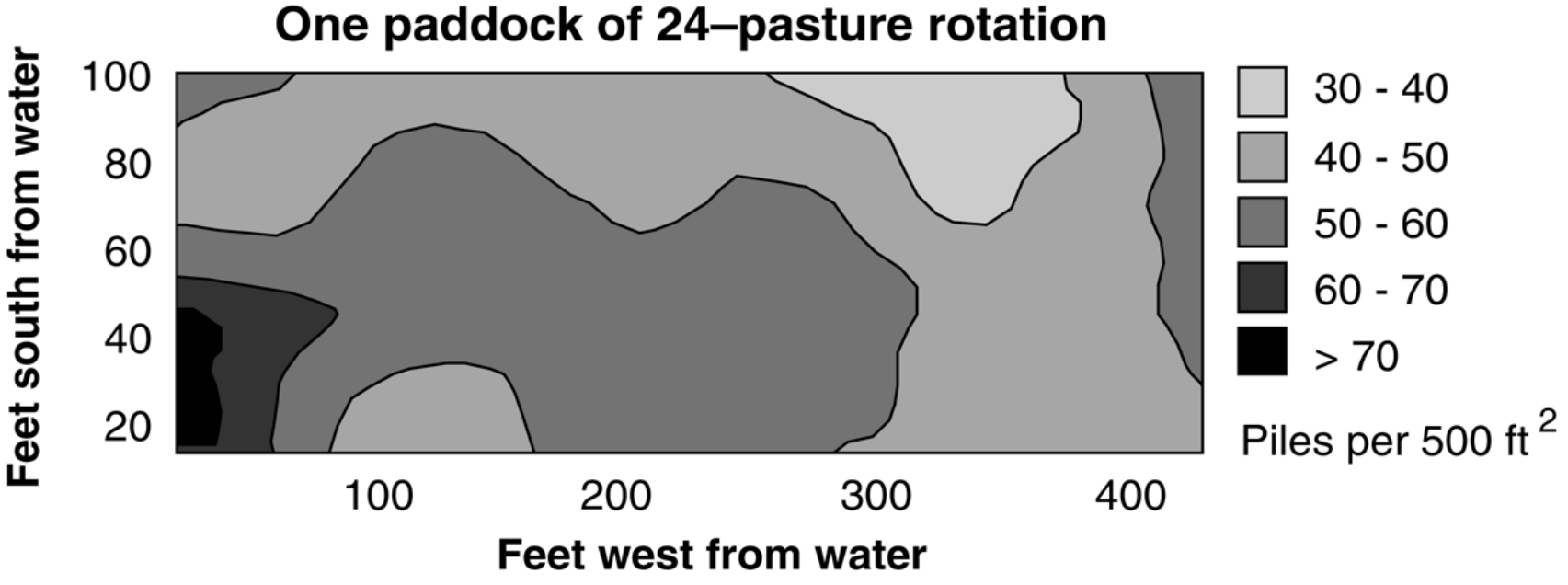
Management intensive grazing improves manure distribution.

Nutrient removal with continuous grazing similar to haying.

Cows as Fertilizer Spreaders!

Manure Distribution





Manure Distribution

Rotation Frequency	Years to get 1 pile / sq. yard
Continuous	27
14 day	8
4 day	4-5
2 day	2

Manure Distribution

What happens
in the paddock with N?

Manure creates a patchwork of high and low N areas in the paddock.

Consequences:
Manure N can reduce fertilizer N need…

But will be of little use if you need maximum yield.

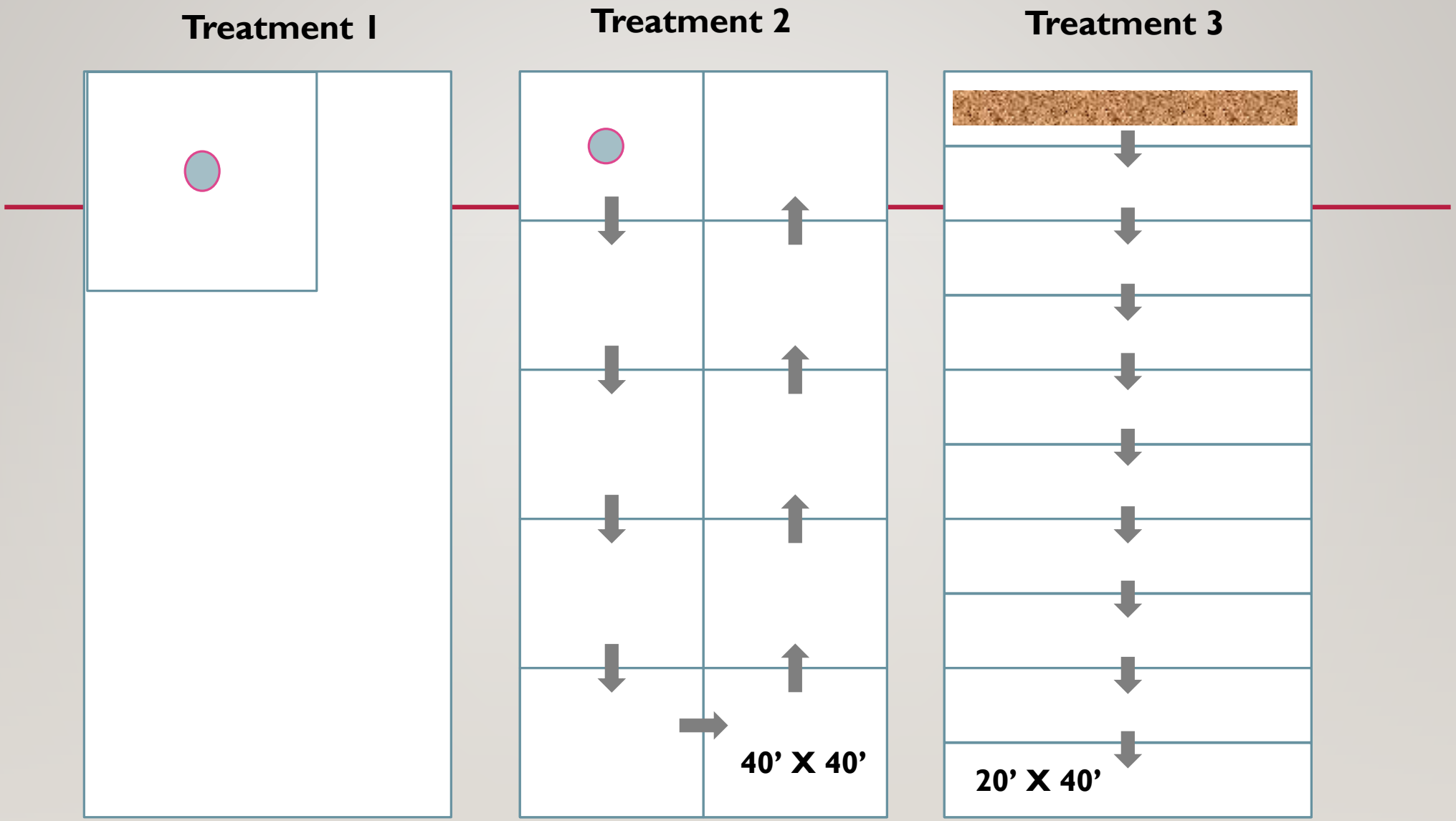
Manure Distribution

What happens
in the paddock with P2O5?

Manure piles provide multiple years of P.

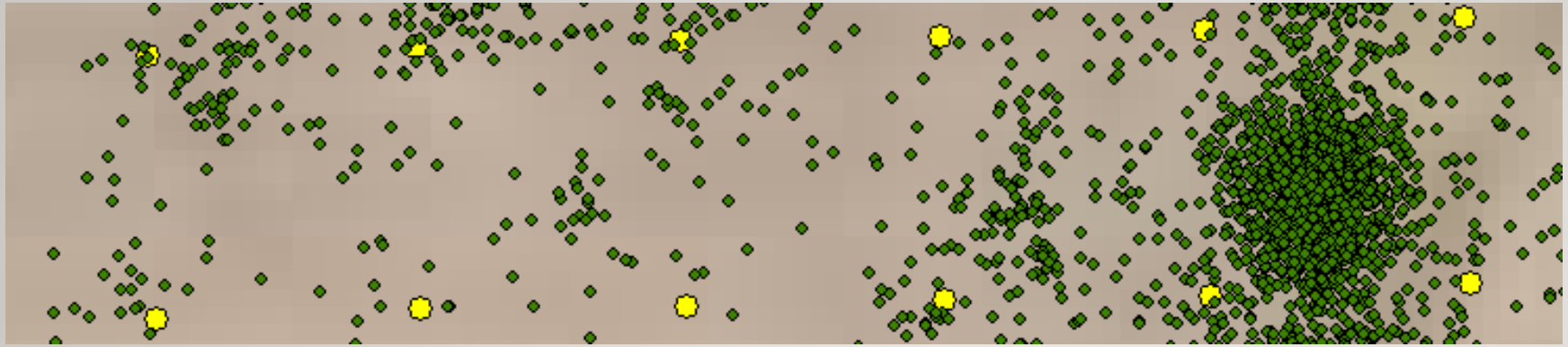
Consequences:
Manure P can meet P need…

But need good manure distribution to insure all of paddock benefits.

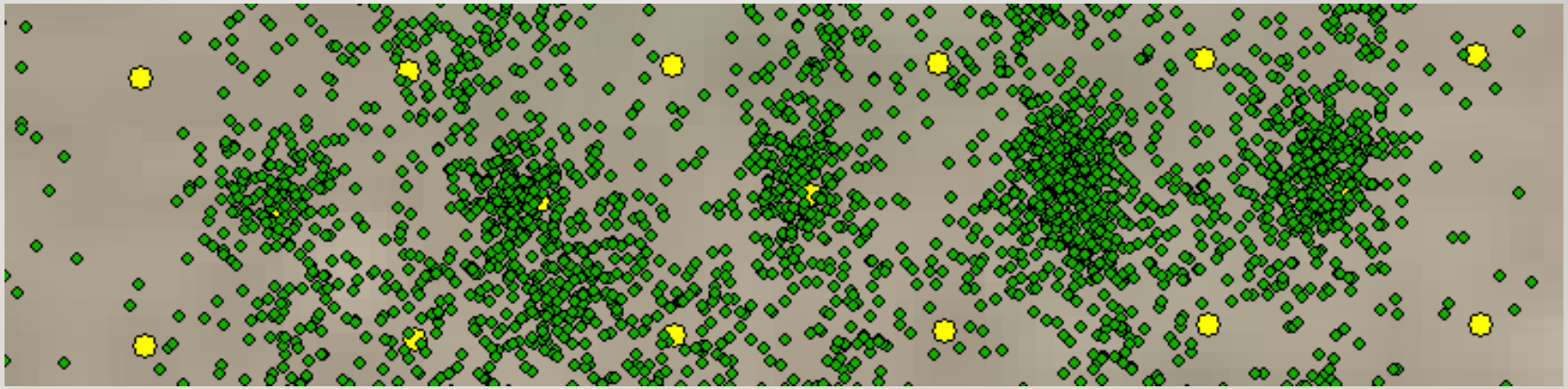

Treatment 1
Treatment 2
Treatment 3
40’ X 40’
20’ X 40’
Hay Ring in Set Feeding Area
Move Hay Ring Every Other Day
Unroll Hay in a New Spot Daily

Manure Distribution – GPS Collar Data

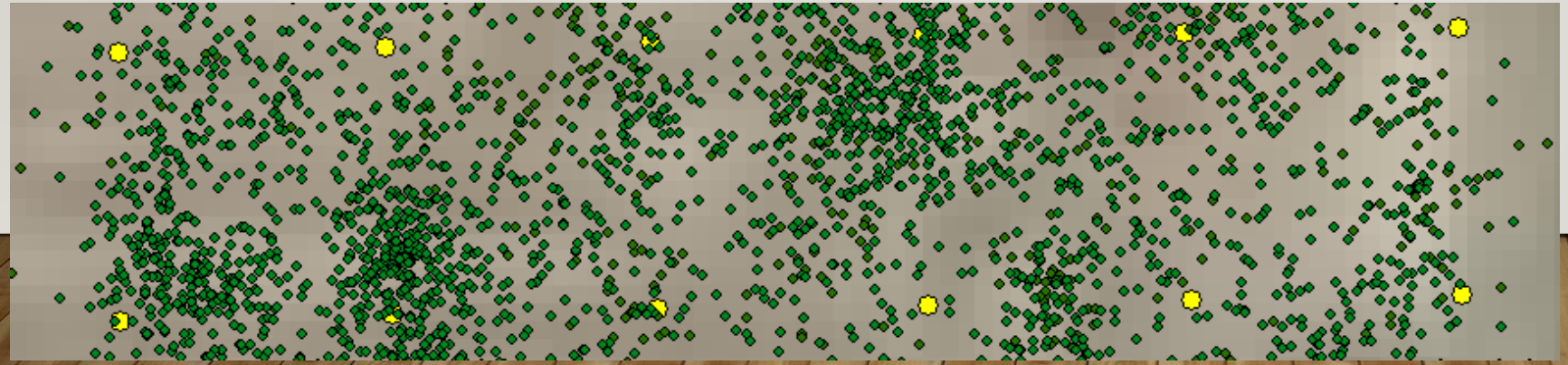
Stationary Ring



Moving Ring



Unrolling Hay



RECIPE FOR SUCCESS

- Regularly move feeders and feeding areas around the pasture.
- Increase the stocking density of animals but move animals more frequently.
- Do not use the same pasture for supplemental feeding every year.
- Maintain a setback area of at least 100 feet between supplemental feeding areas and streams.

Conclusions:

- Imported feed = fertilizer for your farm.

FINAL THOUGHT

- If you choose to disconnect with and/or disregard the largest investment on the farm (the land itself) then how can you continue to maximize profit over the long run of your operation.