HOW TO ECONOMICALLY USE FERTILIZER IN PASTURE-BASED DAIRY SYSTEMS

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BEFORE YOU FERTILIZE…ASK "WHY?"

- Some good reasons to fertilize
  - You expect good growing conditions AND need additional feed
  - You want to change forage growth patterns to meet animal feed needs
  - You want to strategically use fertilizer to encourage one type of forage plant over another
  - The cost to grow additional forage with fertilizer is less than it would cost to purchase more forage or additional feed

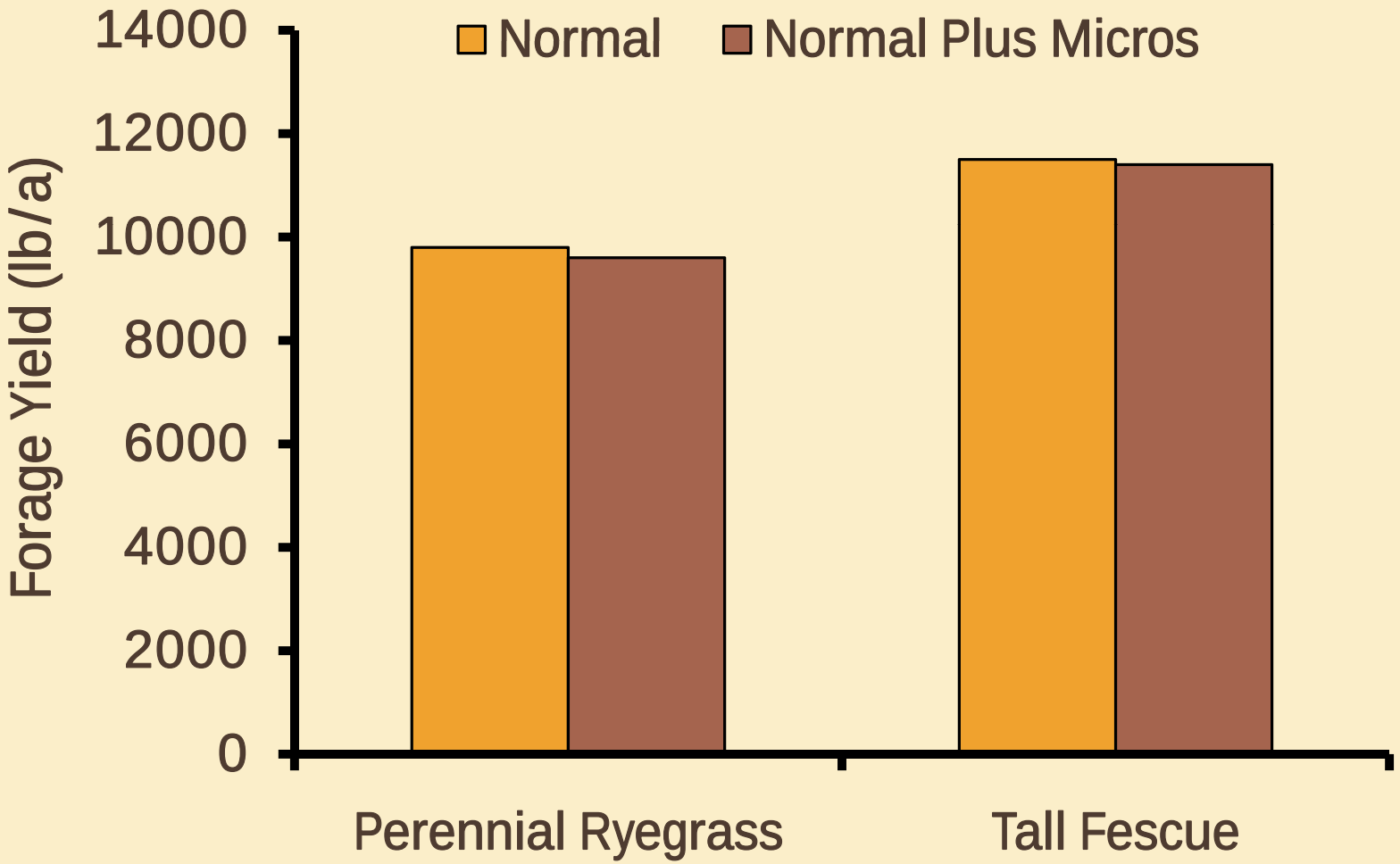
WHAT NUTRIENTS DO PLANTS REQUIRE?

- Macro-nutrients - N, P, K, Ca, Mg, S
  - N most likely to be economic for dairy systems
  - P, K most likely needed in farm development but less likely to be required as the system matures
  - S is a growing concern
- Micro-nutrients - B,Fe,Cu,I,Mn,Mo,Zn,Cl,Na,Co,Si
  - Unlikely to show economic responses unless severely deficient
- Soil pH – not a nutrient, but regulates the availability of nutrients to plants

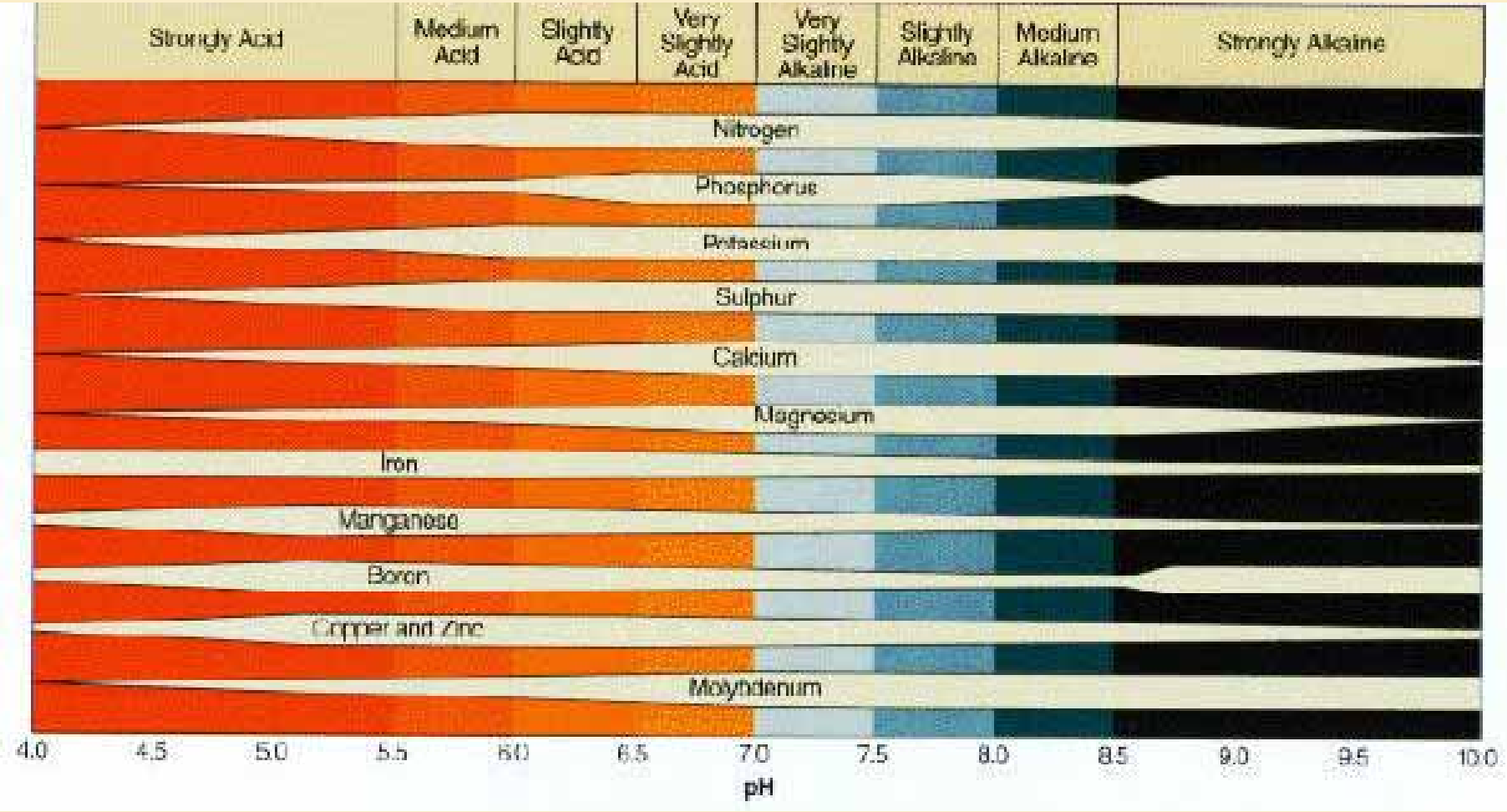
OTHER NUTRIENTS

- Often sold as “micro-blends” or foliar sprays
- Expensive….some blends costs as much as $100 per acre
- Almost all research shows little economic response in pastures
- Boron may be an exception for pastures that include alfalfa

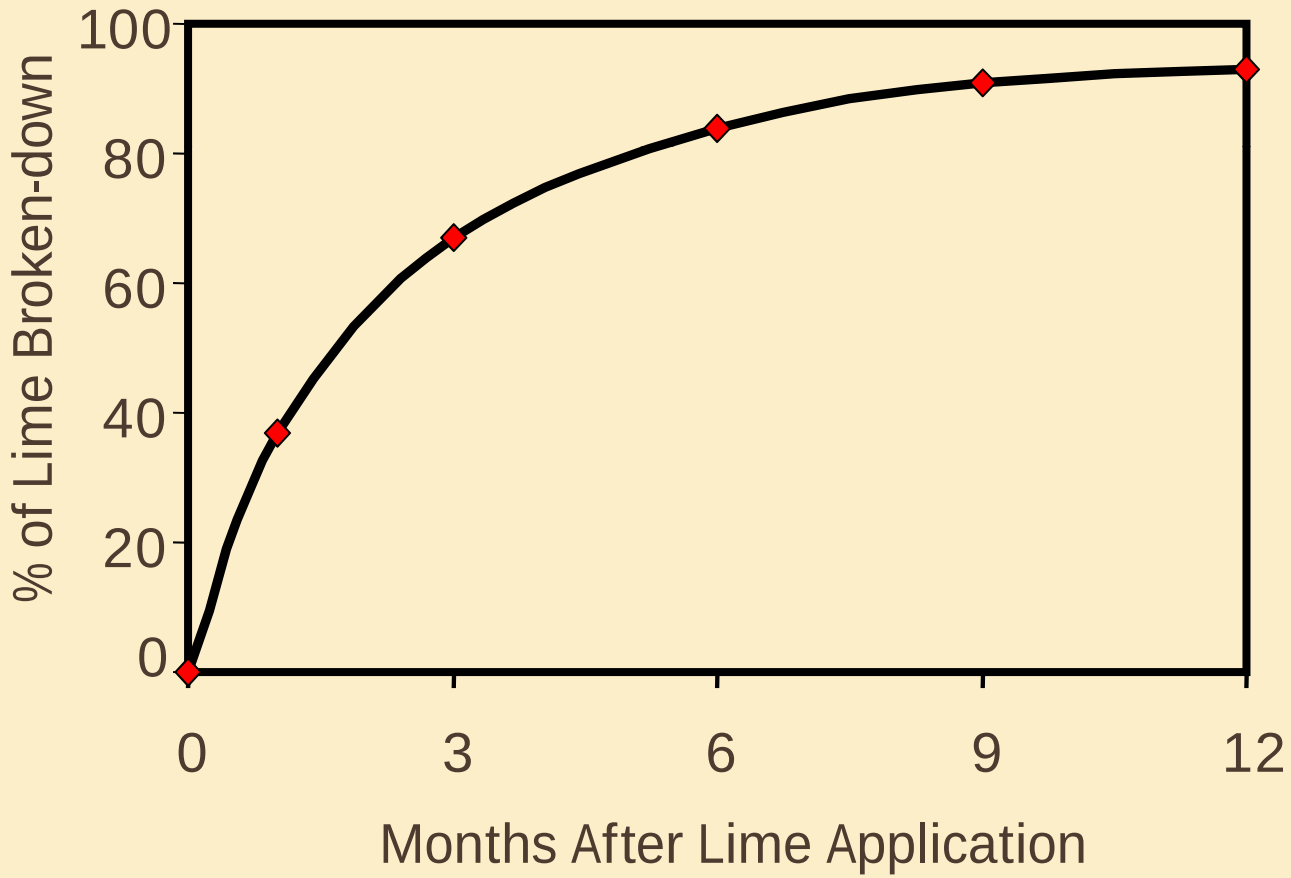
OTHER NUTRIENTS



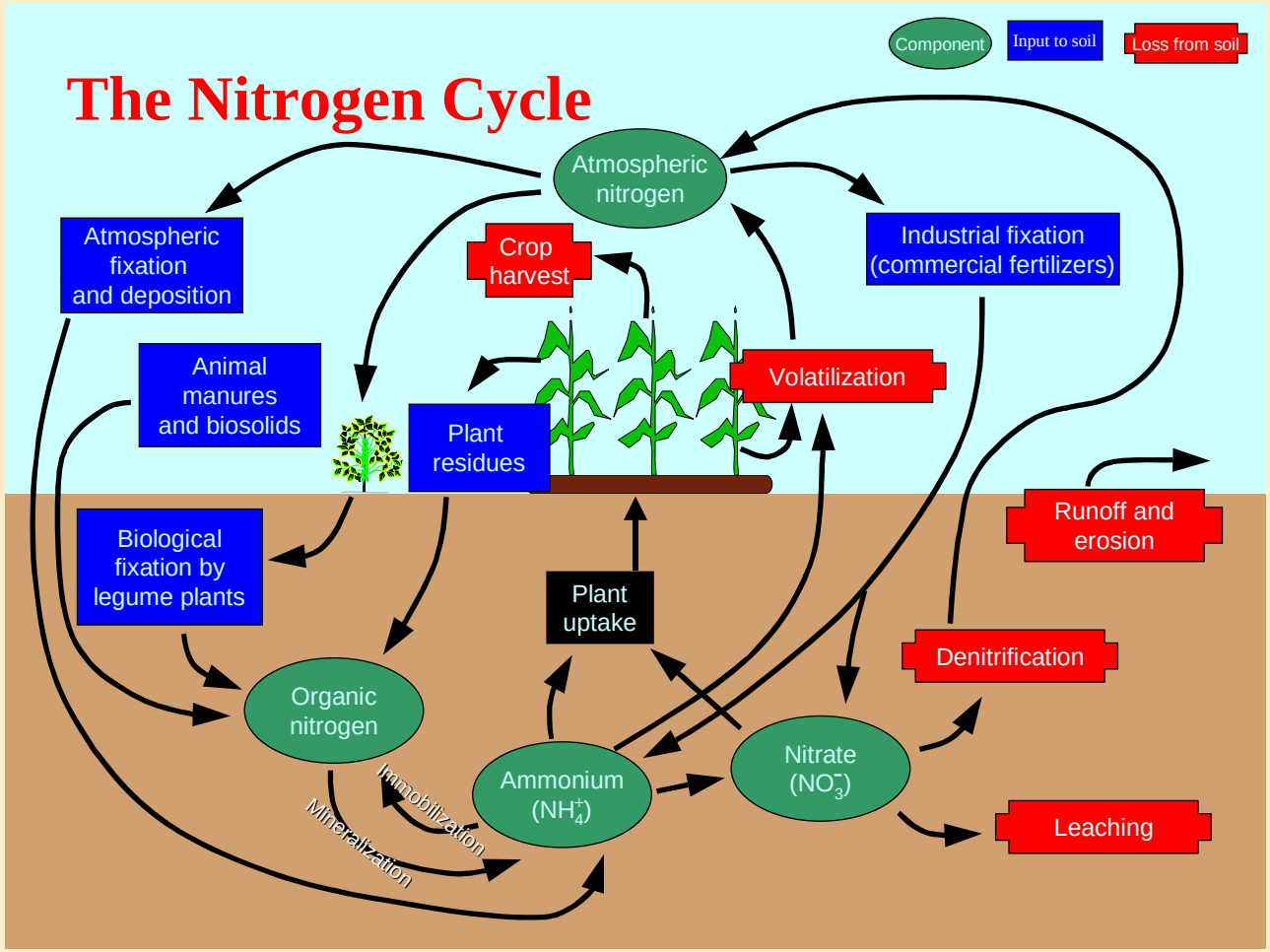
SOIL pH – THE REGULATOR



LIME TAKES A WHILE

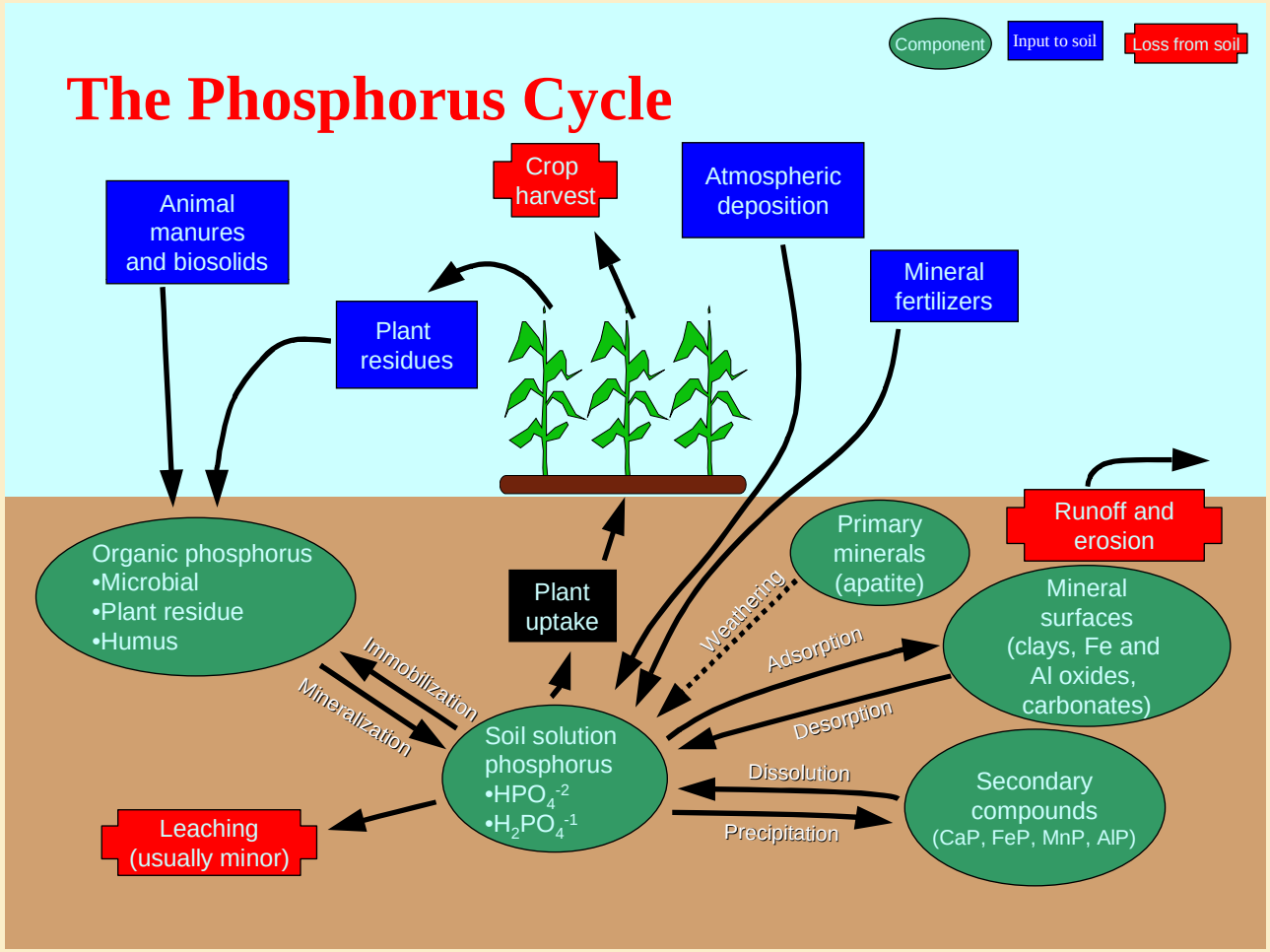


MACRONUTRIENTS



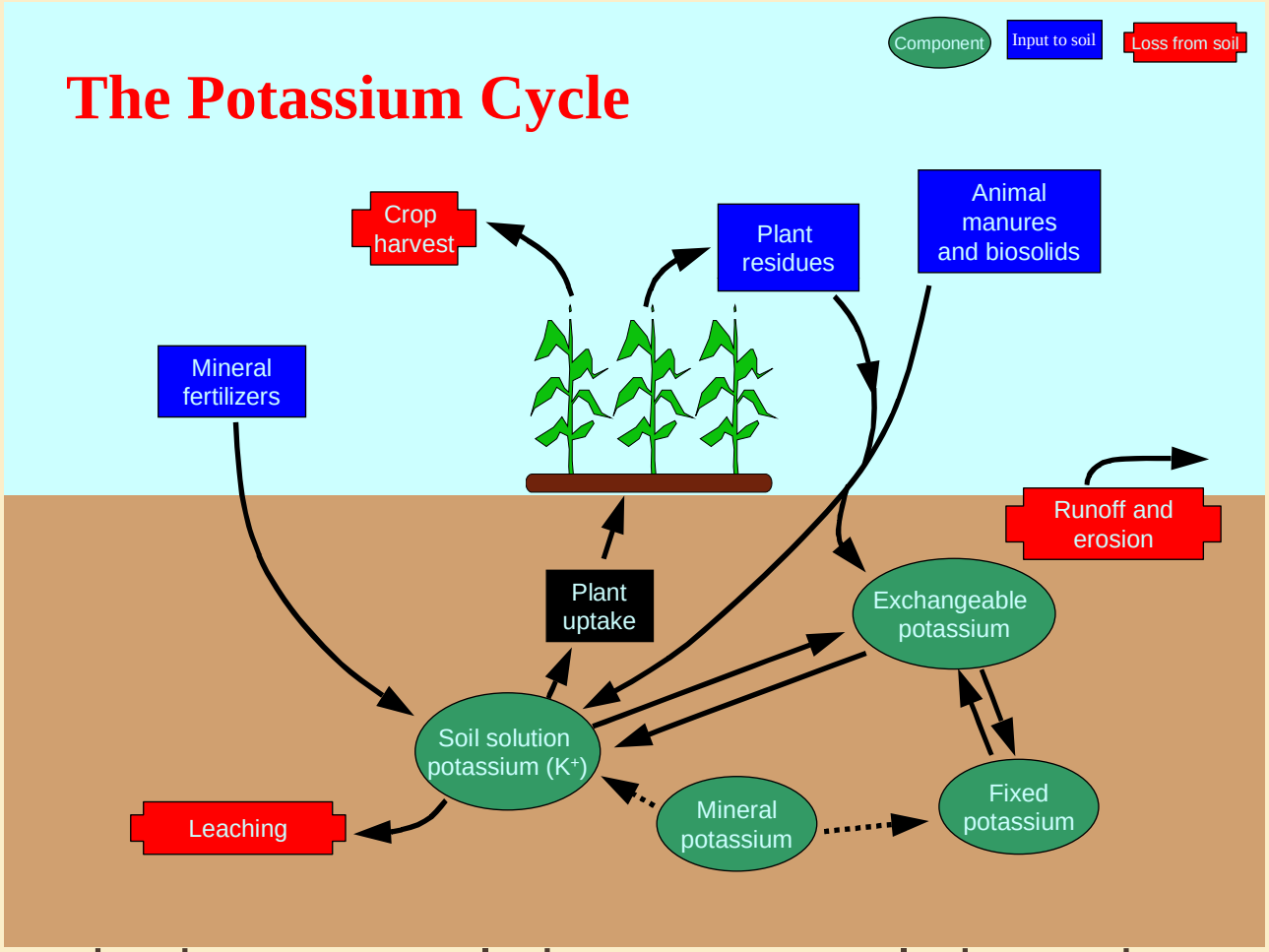
- The building block of proteins (enzymes), chlorophyll, DNA, RNA

MACRONUTRIENTS



- Storage and transfer of energy

MACRONUTRIENTS



- Enzyme activation, water relations, energy relations, nitrogen uptake, translocation, starch synthesis

DETERMINING PLANT NEEDS

- Determine nutrients in grain or hay
- Replace the nutrients removed from soil

NUTRIENT CONTENT OF CROPS

Crop	N	P_2O_5	K_2O
	----- lb / acre -----		
Corn (150 bu.)	165	53	38
Wheat (50 bu.)	65	32	25
Alfalfa (6 ton)	270*	90	270
Cool-season grass (3 ton)	150	40	145

PASTURE FERTILITY NEEDS ARE COMPLEX

PASTURE FERTILITY

- Fertilizer requirements for pastures are different than for cropping systems or even hay production
  - Roughly,75 to 90% of phosphorus (P) and potassium (K) are returned to the soil
  - About ¼ to ½ of the nitrogen applied to pasture as manure or urine is returned...about ½ to ¾ lost
- It takes about 40 to 50 lb of N to grow 1 ton of cool-season grass

NUTRIENT REMOVAL FROM PASTURE

Crop	N	P_2O_5	K_2O
	----- lb / acre -----		
Alfalfa hay (6 ton)	270*	90	270
Cool-season grass hay (3 ton)	150	40	145
Pasture-based dairy[1]	*120*	*-9*	*-65*

[1]Assumes 1.5 tons of grain feeding per day + 0.8 ton of hay annually

PASTURE FERTILIZATION STRATEGIES

- Establish fertility levels adequate for target species
  - P, K, and lime most critical to begin farm development
- Distribute nutrients excreted by livestock evenly over the pasture system
  - Typically, not a major issue if grazing management is right
- Use N fertilizer to provide additional feed ONLY when needed

SPECIES DIFFER IN NUTRIENT NEEDS

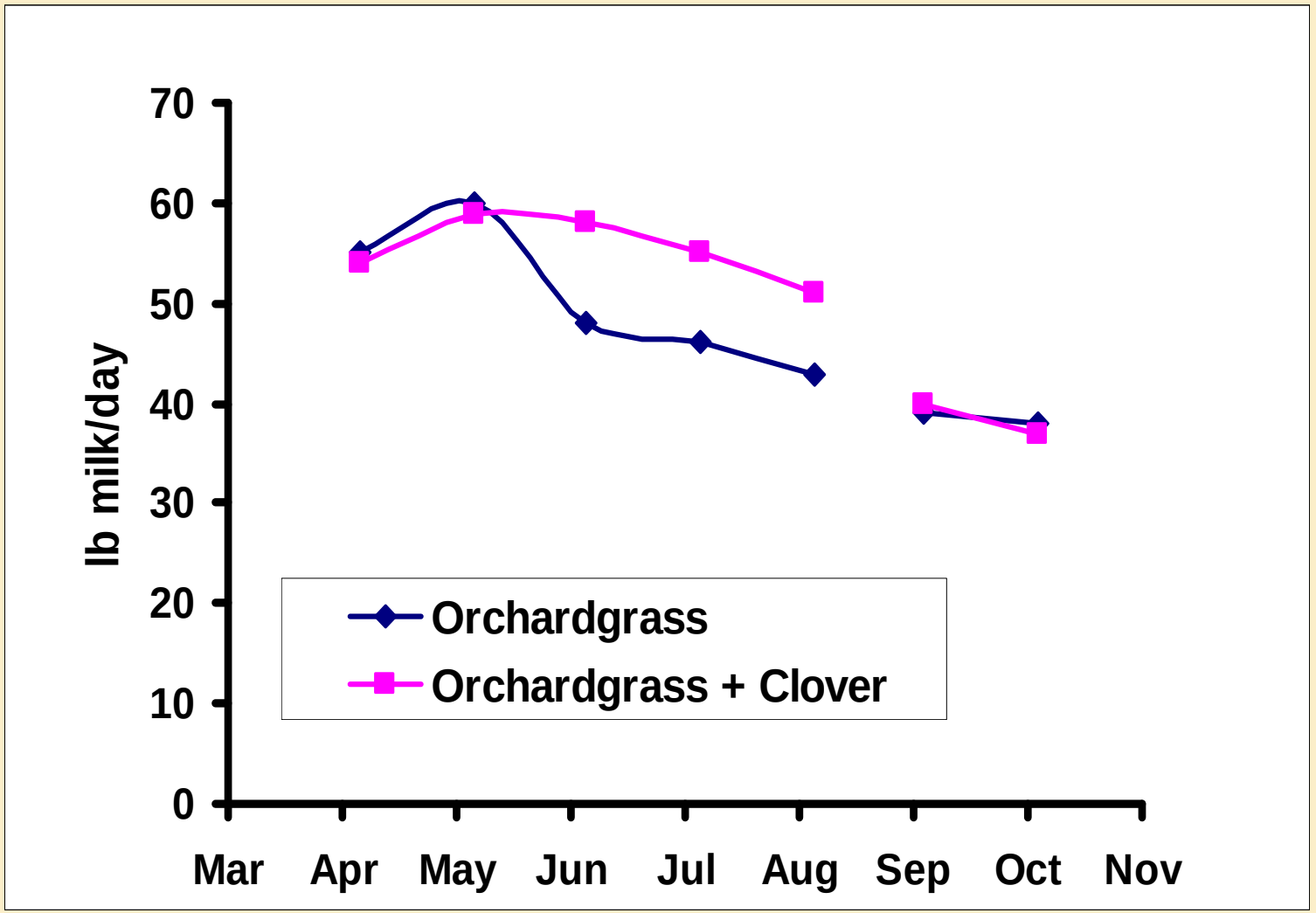
MINIMUM SOIL TEST REQUIREMENTS

Species	pH(s)	P	K
		- lb / acre -	
Cool-season grasses	5.0	20	200
Warm-season grasses	5.0	20	200
Alfalfa	6.5	40	300
Red Clover	6.0	25	250
White Clover	5.5	25	250
Birdsfoot Trefoil	5.5	20	225
Lespedeza	5.0	20	200

LEGUMES

- Provide nitrogen (N)
- Have higher P and K needs are require higher soil pH
- Higher quality than most grasses
- Better yield distribution

THE BENEFIT OF GRASS/LEGUME MIXES



Virginia

ANATOMY OF A ROOT NODULE

Picture from Michael Russelle, USDA-ARS

HOST-BACTERIA SPECIFICITY

Host	Rhizobia
Soybean	*Bradyrhizobium japonicum*
Alfalfa	*Sinorhizobium meliloti*
Trefoil	*Mesorhizobium loti*
Vetch	*Rhizobium leguminosarum* bv *viciae*
Clovers	bv *trifolii*

N_2 FIXATION IN MIXED STANDS

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

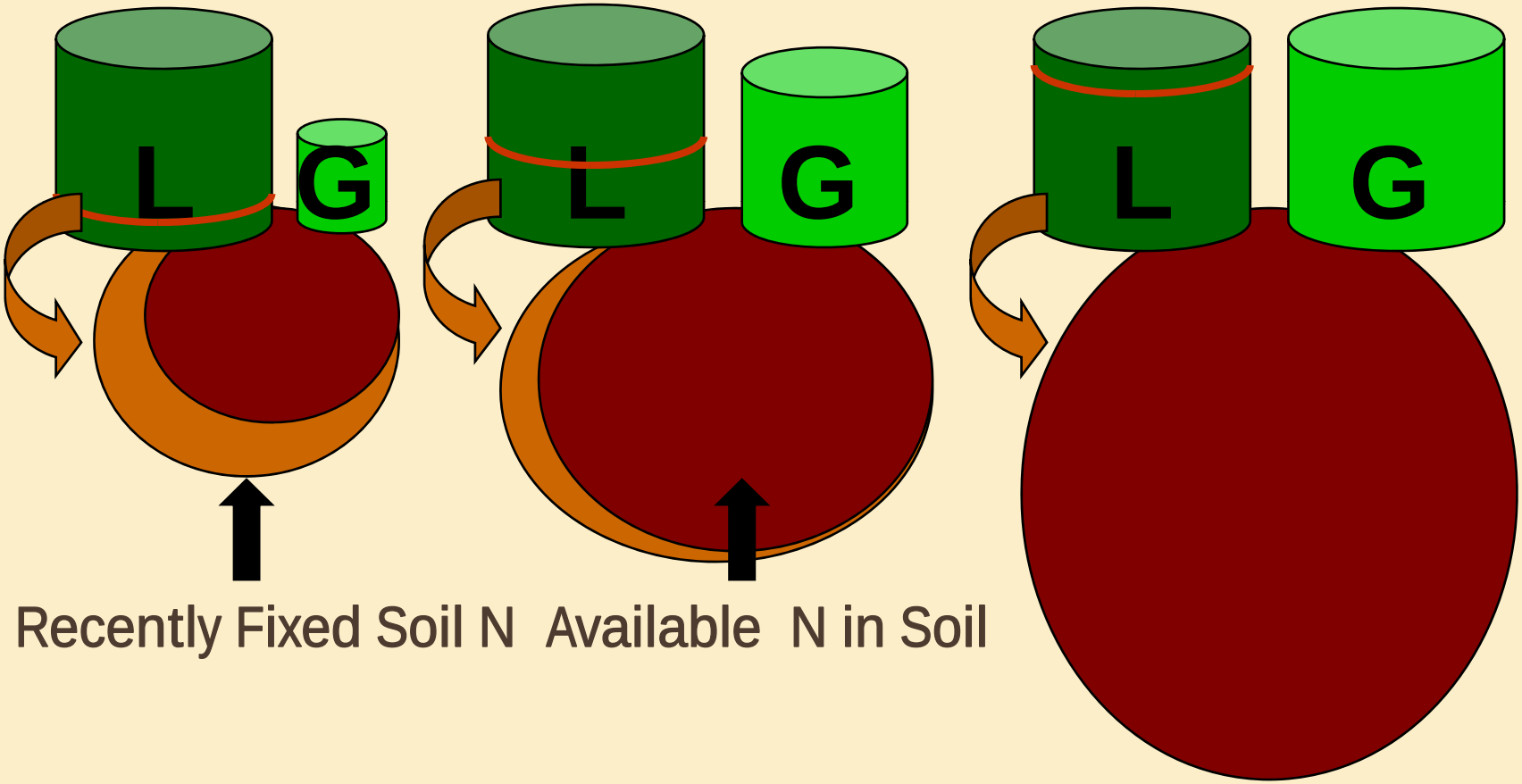
(Ledgard and Steele, 1992; West and Mallarino, 1996)

TRANSFER OF FIXED N TO GRASS

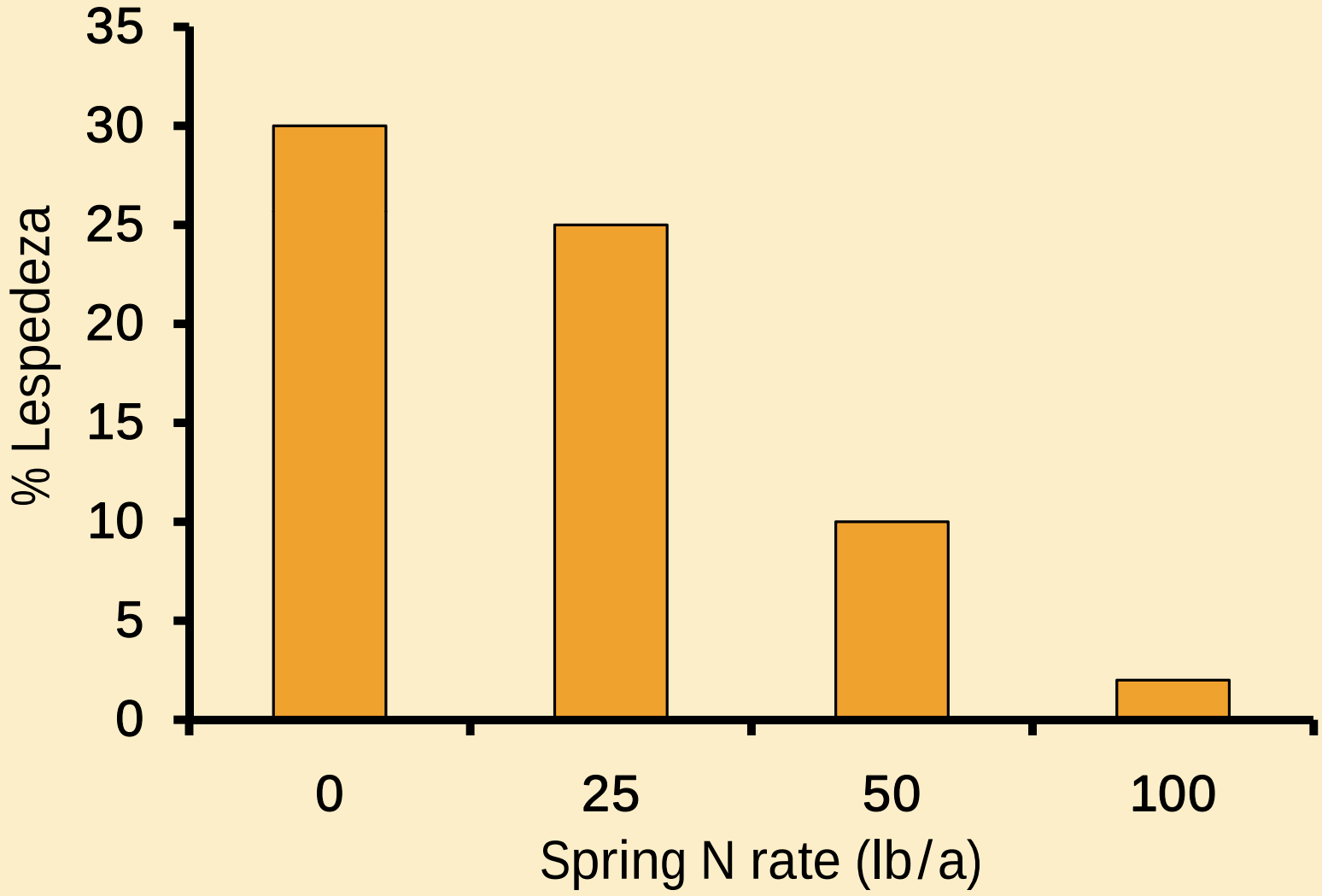
- 10 - 50 lb. N/acre/yr
- 10 - 20% of the N fixed is transferred
- 10 - 50% of grass N is from legume

(West and Mallarino, 1996)

LEGUME/GRASS CYCLE



N FERTILIZATION OF MIXED PASTURE



WHAT N FERTILIZER SHOULD I USE?

- Lots of effective N fertilizer products
  - Urea, ammonium nitrate and ammonium sulfate most common
- Several effective ‘new’ products sold
  - Typically urea with some sort of coating
- Several ‘new’ ineffective foliar sprays and products
  - Expensive….some blends costs as much as $100 per acre
  - Almost all research shows little or no economic response in pastures

N FERTILIZER SOURCES/MIXTURES

Fertilizer Source	For mixture treatments	
	Rate of S applied (lb/acre)	% N derived from ESN and/or Urea
Ammonium Nitrate	-	-
Urea	-	-
Ammonium Sulfate	-	-
Urea treated with Agrotain	-	-
ESN polymer coated Urea	-	-
Nurea	-	-
Nurea with 10% polymer N	-	-
Ammonium Sulfate (10S)/Urea	10	88
Ammonium Sulfate (20S)/Urea	20	75
Ammonium Sulfate (40S)/Urea	40	53
Ammonium Sulfate (10S)/ESN	10	88
Ammonium Sulfate (20S)/ESN	20	75
Ammonium Sulfate (40S)/ESN	40	53
1/3 each Ammonium Sulfate + ESN + Urea	28.6	67
Unfertilized Control	-	-

SPRING APPLICATION

Fertilizer Source	Spring Forage Yield				
	Southern Missouri			Central Missouri	
	2005	2006	2007	2006	2007
	---------- (lb/acre) ----------				
Ammonium nitrate	8081	3974	3648	4603*	4827
Urea	7780	3681	3140	4038	4717
Ammonium sulfate	8834*	3988*	4184*	4408	4916*
Urea with Agrotain	8300	3874	3787	4188	4686
ESN coated Urea	7134	2115	3372	2739	3673
Nurea	8142	3409	3401	4196	4564
Nurea + 10% poly N	7368	3625	3402	3919	4309
Unfertilized Control	4232	1654	1566	1688	2167
LSD (0.05)	916	570	371	708	491

SOIL pH IN SPRING 2007

Fertilizer Source	Southern Missouri	Central Missouri
	------- Soil pH(s) -------	
Ammonium Nitrate	5.92	6.92
Urea	5.86	6.92
Ammonium Sulfate	5.62	6.76
Urea treated with Agrotain	6.08*	7.16
ESN polymer coated Urea	5.92	6.84
Nurea	5.94	6.90
Unfertilized Control	5.84	6.96
LSD (0.05)	0.33	NS

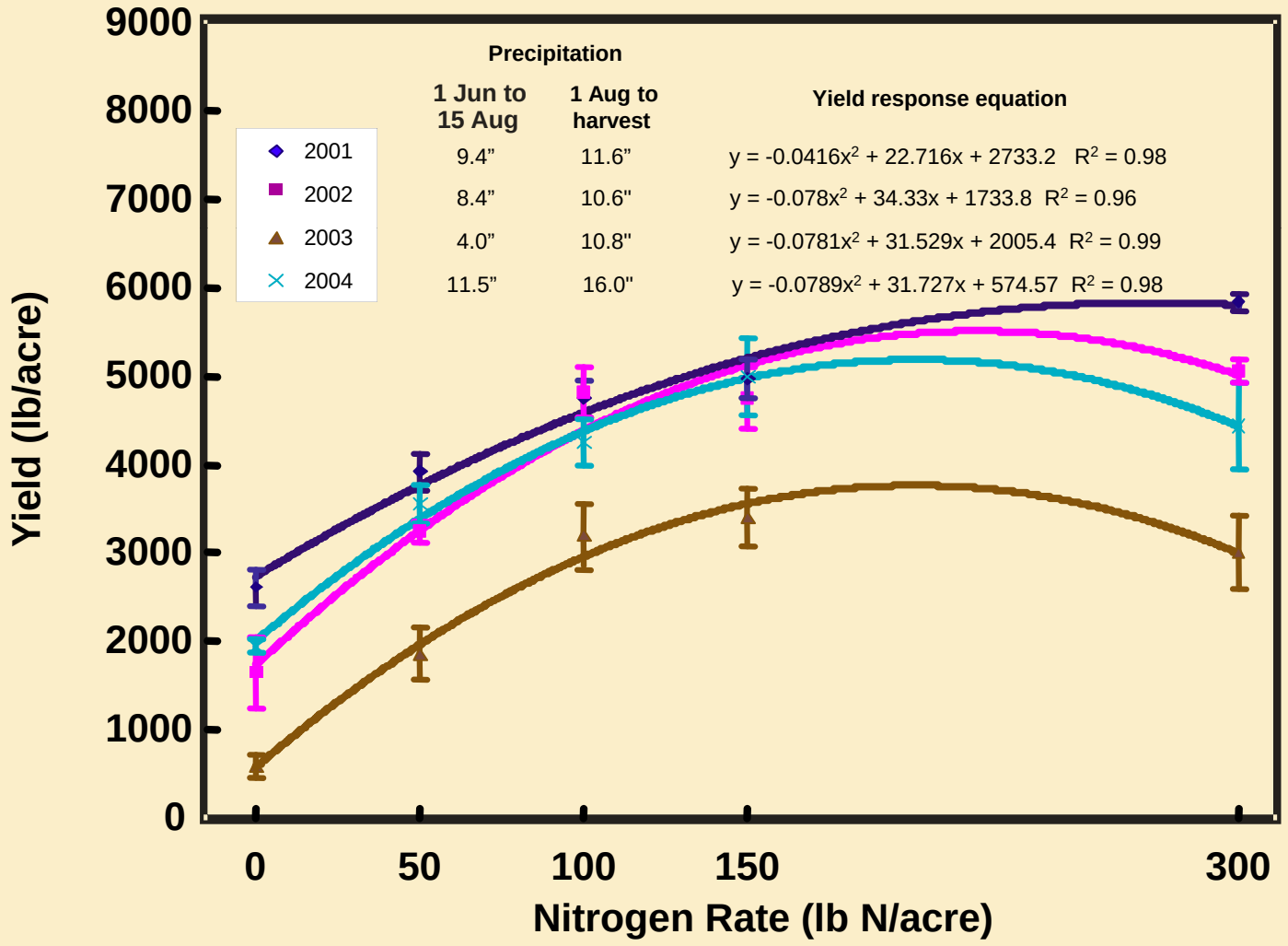
FALL APPLICATION

Fertilizer Source	Autumn Forage Yield			
	Southern Missouri		Central Missouri	
	2005	2006	2006	2007
	---------- (lb/acre) ----------			
Ammonium nitrate	1932*	1918	2700	2483*
Urea	1245	2201	2865*	1935
Ammonium sulfate	1579	2245*	2787	2325
Urea with Agrotain	1523	1880	2696	2287
ESN coated Urea	1249	1549	2117	1826
Nurea	1437	2188	2738	2167
Nurea + 10% poly N	988	2176	2725	2003
Unfertilized Control	492	834	1721	1370
LSD (0.05)	522	616	586	430

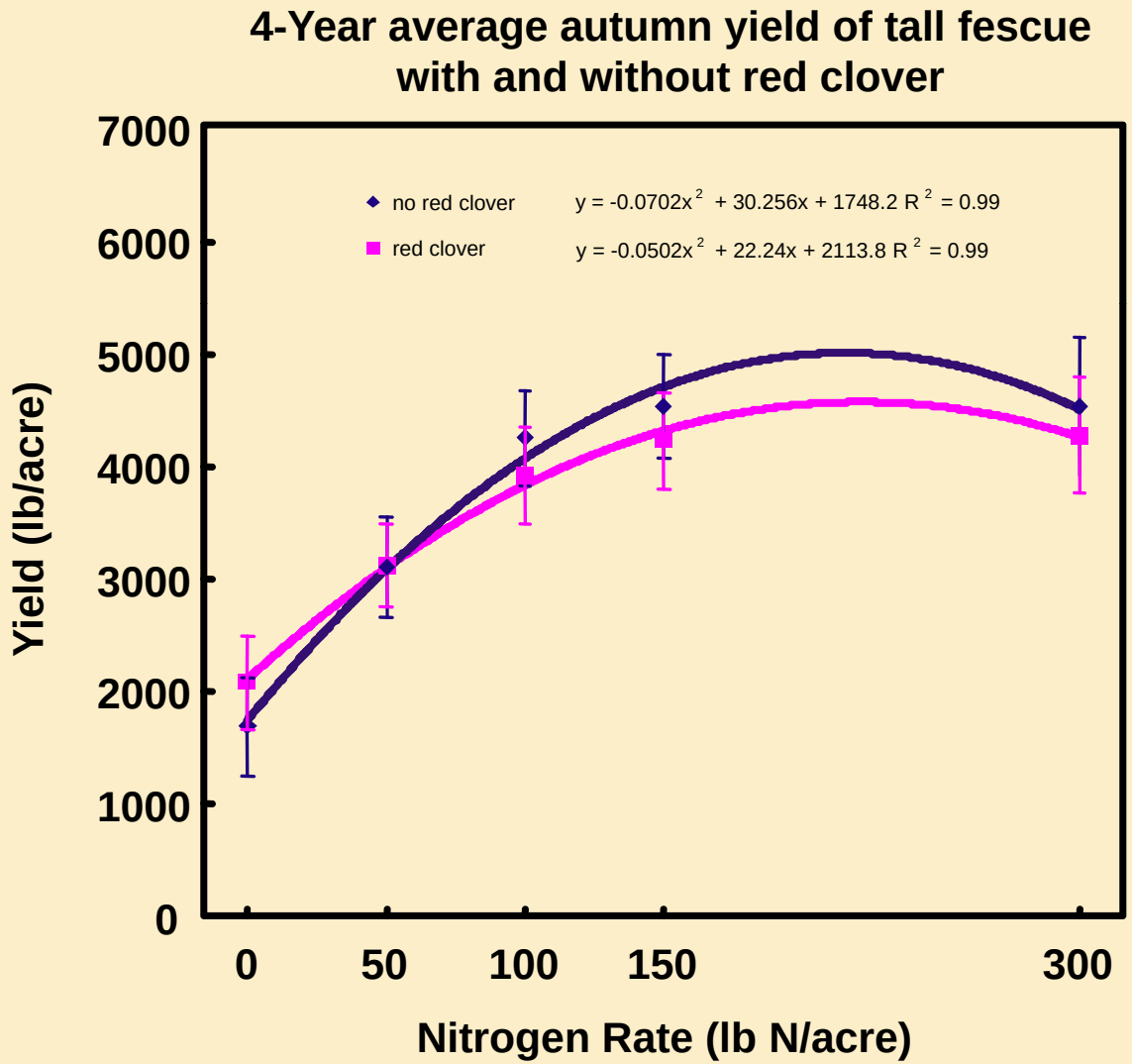
N FERTILIZER FORM CONCLUSIONS

- Ammonium sulfate consistently in the top group
- Ammonium nitrate and urea treated with Agrotain, are also consistently effective products
- Urea (untreated) somewhat variable, effective if it rains, not so good when dry weather follows application
- ESN and mixtures with ESN appear to lag behind other treatments, especially in spring
- Mixtures of fertilizer products show little benefit to this point

CSG RESPONSE TO LATE-SUMMER N

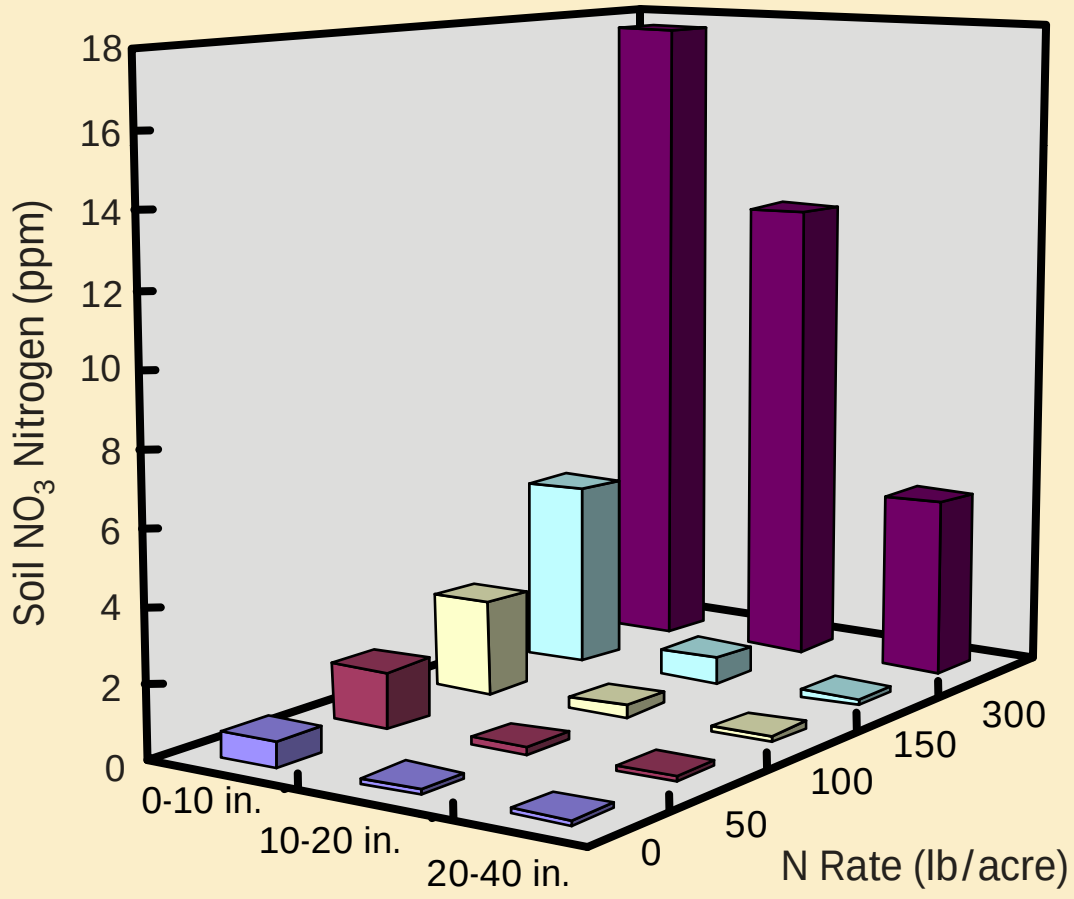


MIXED VS. PURE GRASS SWARD



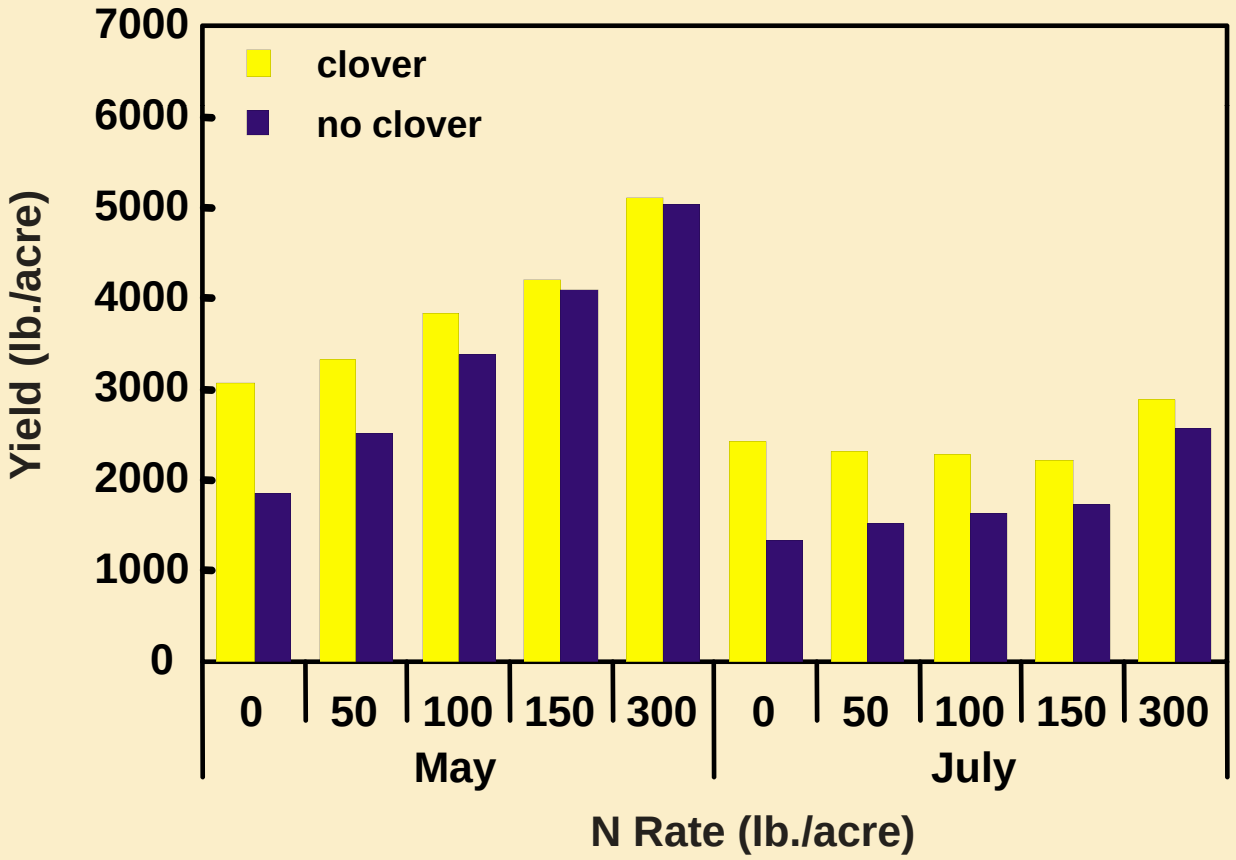
SOIL NITRATE THE FOLLOWING SPRING

Average spring concentration of NO_3 in the soil profile when tall fescue was fertilized the previous autumn. Data from near Linneus, MO.



FORAGE YIELDS THE FOLLOWING YEAR

Four-year average May and July yields of tall fescue with and without red clover and treated with different levels of N the previous fall



RED CLOVER STANDS THE NEXT SPRING

RED CLOVER STANDS THE NEXT SPRING

N rate	2002	2003	2004	2005
	---- Red clover plants per ft^2 ----			
0	2.3	9.4	2.0	3.0
50	1.6	7.7	1.7	1.5
100	0.8	5.3	1.3	0.9
150	0.8	3.3	0.7	0.9
300	0.3	0.8	0.2	0.2
LSD (0.05)	0.4	1.6	0.5	0.8

LATE SUMMER (FALL) N APPLICATIONS

- Yield responses nearly linear to 100 lb/acre of N
- Having clover in the stand gives a similar yield to grass alone
- Red clover stands are thinner but probably acceptable when up to 100 lb/of N per acre is applied in late summer
- Soil nitrate levels are low in all treatments except where unrealistic N rates are applied

FERTILIZATION DATE MATTERS

	Fertilization date		
N response	March 15	May 15	Aug 15
lb DM/lb N	25	15	20

BUYING GUIDE (25 LB RESPONSE)

Corn Price ($/bu)	Fertilizer Price ($/lb)				
	0.40	0.50	0.70	0.90	1.10
3.00	Fertilize	Fertilize	Buy Corn	Buy Corn	Buy Corn
3.50	Fertilize	Fertilize	Fertilize	Buy Corn	Buy Corn
4.00	Fertilize	Fertilize	Fertilize	Buy Corn	Buy Corn
4.50	Fertilize	Fertilize	Fertilize	Fertilize	Buy Corn
5.00	Fertilize	Fertilize	Fertilize	Fertilize	Buy Corn
5.50	Fertilize	Fertilize	Fertilize	Fertilize	Fertilize
6.00	Fertilize	Fertilize	Fertilize	Fertilize	Fertilize

Assumes 65% utilization rate of forage. Forage contains 0.68 NEl

BUYING GUIDE (20 LB RESPONSE)

Corn Price ($/bu)	Fertilizer Price ($/lb)				
	0.40	0.50	0.70	0.90	1.10
3.00	Fertilize	Fertilize	Buy Corn	Buy Corn	Buy Corn
3.50	Fertilize	Fertilize	Buy Corn	Buy Corn	Buy Corn
4.00	Fertilize	Fertilize	Fertilize	Buy Corn	Buy Corn
4.50	Fertilize	Fertilize	Fertilize	Buy Corn	Buy Corn
5.00	Fertilize	Fertilize	Fertilize	Buy Corn	Buy Corn
5.50	Fertilize	Fertilize	Fertilize	Fertilize	Buy Corn
6.00	Fertilize	Fertilize	Fertilize	Fertilize	Buy Corn

Assumes 65% utilization rate of forage. Forage contains 0.68 NEl

BUYING GUIDE (15 LB RESPONSE)

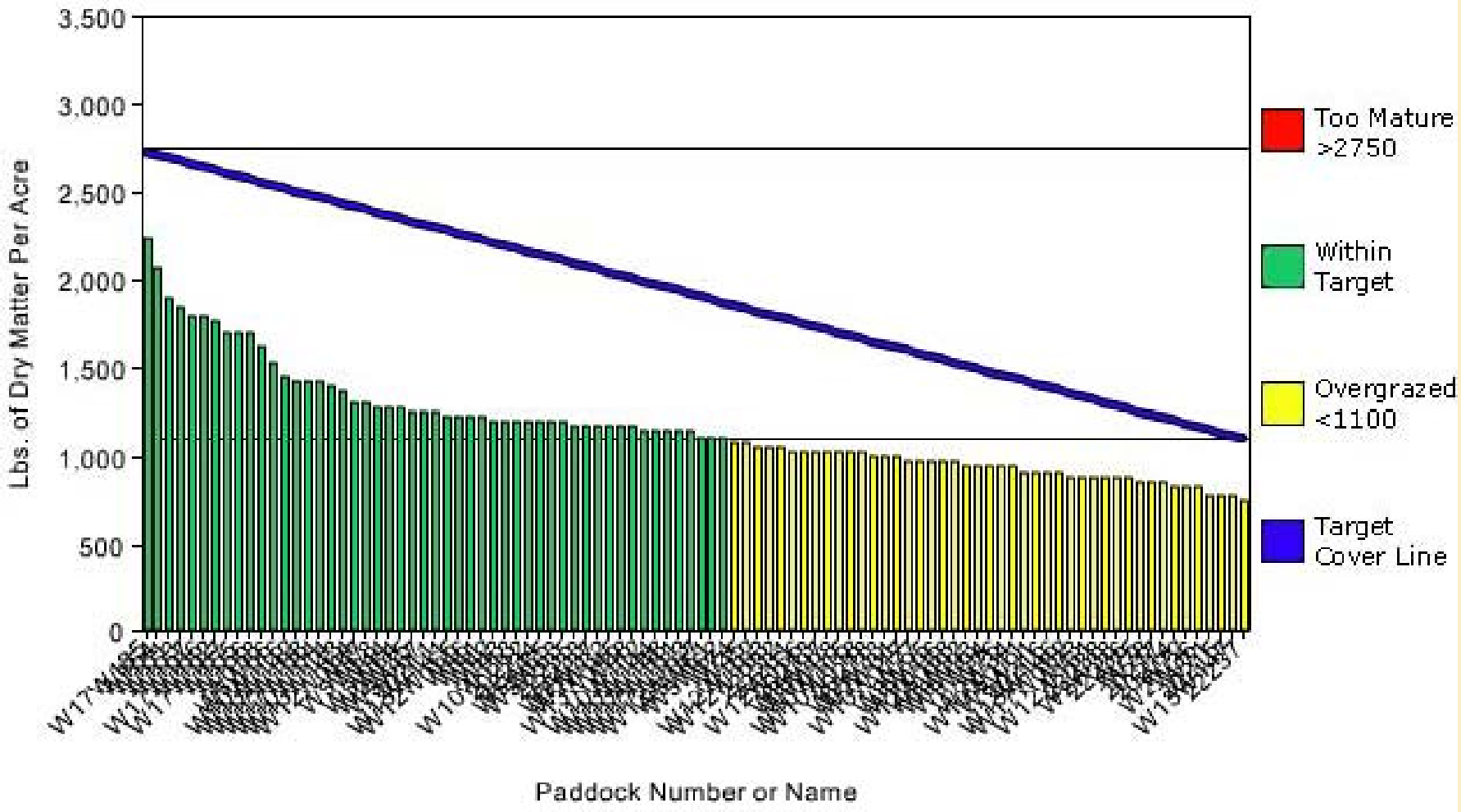
Corn Price ($/bu)	Fertilizer Price ($/lb)				
	0.40	0.50	0.70	0.90	1.10
3.00	Buy Corn	Buy Corn	Buy Corn	Buy Corn	Buy Corn
3.50	Fertilize	Buy Corn	Buy Corn	Buy Corn	Buy Corn
4.00	Fertilize	Fertilize	Buy Corn	Buy Corn	Buy Corn
4.50	Fertilize	Fertilize	Buy Corn	Buy Corn	Buy Corn
5.00	Fertilize	Fertilize	Buy Corn	Buy Corn	Buy Corn
5.50	Fertilize	Fertilize	Fertilize	Buy Corn	Buy Corn
6.00	Fertilize	Fertilize	Fertilize	Buy Corn	Buy Corn

Assumes 65% utilization rate of forage. Forage contains 0.68 NEl

OPTIMIZING YOUR N FERTILIZER DOLLAR

- Focus on “Do I need the Forage?”
  - About ¼ of farm 50 lb/acre in early spring
  - Depending on conditions ¼ of farm in late spring
  - About ¾ to all of farm in late summer
  - Perhaps a few other times as feed needs dictate
- Nitrogen can be an excellent or a lousy investment depending on alternative feed costs and growing conditions
- You are only paying for fertility if it allows you to **buy less feed** or **sell more milk**

WOULD ADDING N HERE HELP?



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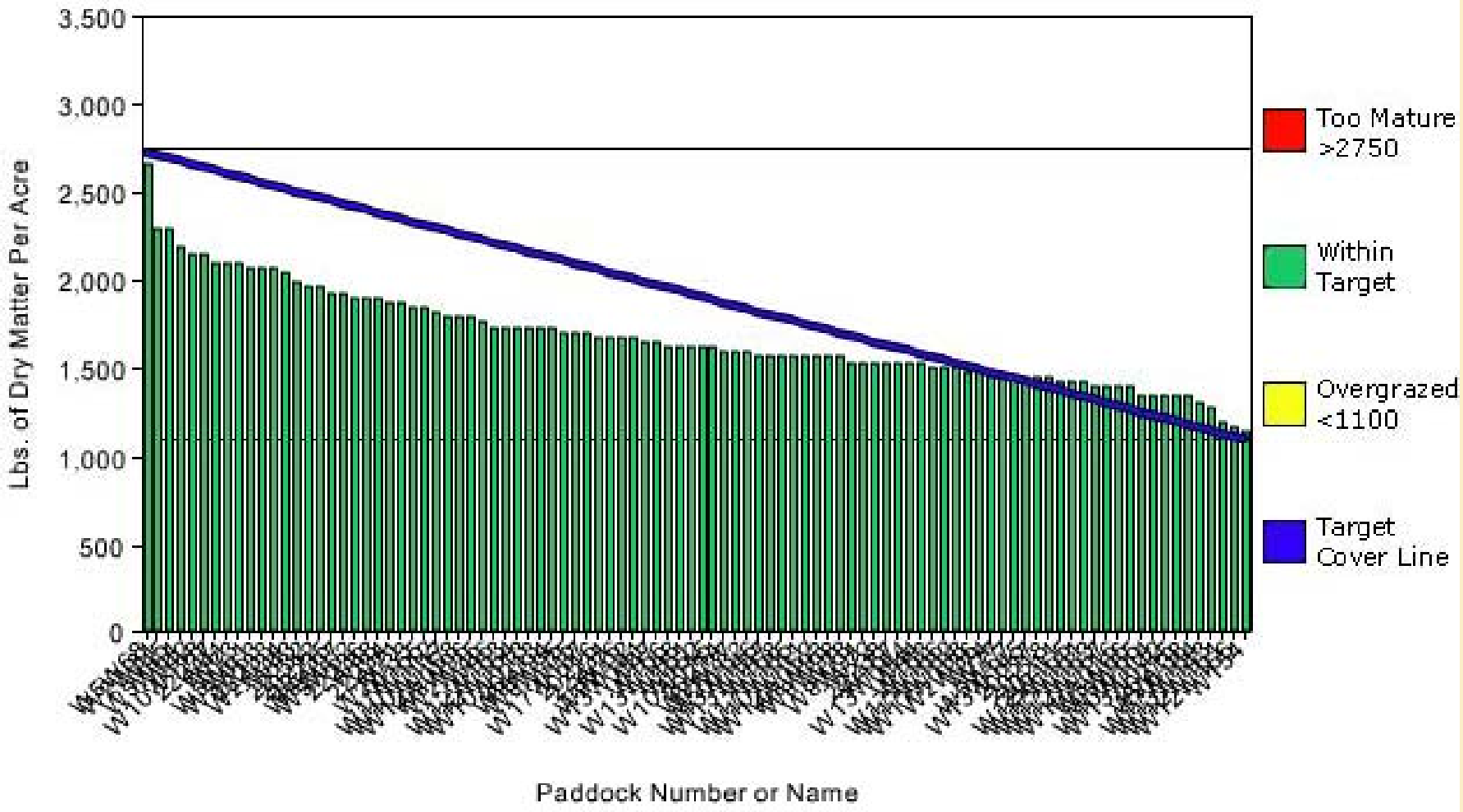

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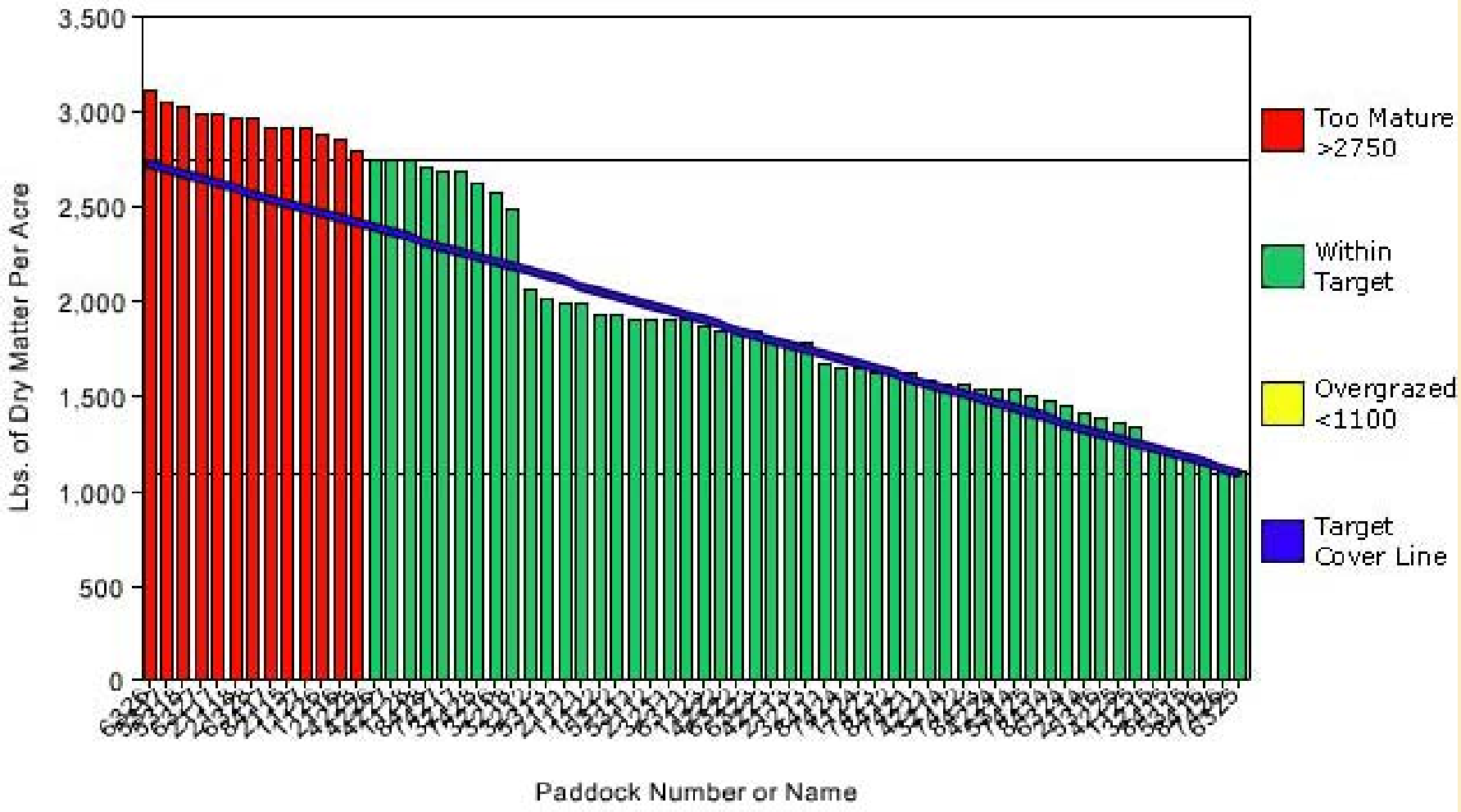

OPTIMIZING INVESTMENT IN FERTILIZER

- Focus on needed nutrients for desired species
  - If needed lime, P and K improve legume survival (and do not hurt grass growth either) and are important in farm development
  - Remember most pasture-based dairy systems in the US do not have a huge removal (even surpluses) of P and K
- Nitrogen can be an excellent or a lousy investment depending on alternative feed costs and growing conditions
- You are only paying for fertility if it allows you to **buy less feed** or **sell more milk**