Phosphorus Feeding Strategies for Dairy: Effects on Manure P and P Cycles

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Differences in nitrogen and phosphorus cycling on dairy farms

Excretion

N in feces and urine

P in feces

Mobility after excretion

N is highly mobile, little soil buildup

P has low mobility, high soil buildup*

Losses after excretion

N: volatilization, leaching, denitrification

P: runoff

*manure application based on crop N requirements results in soil P buildup

Relative to crop need, manure is relatively rich in P and poor in N.

If manure is applied to meet crop N need, then there will be twice as much P as needed.

Range of analyzed manure nutrient content

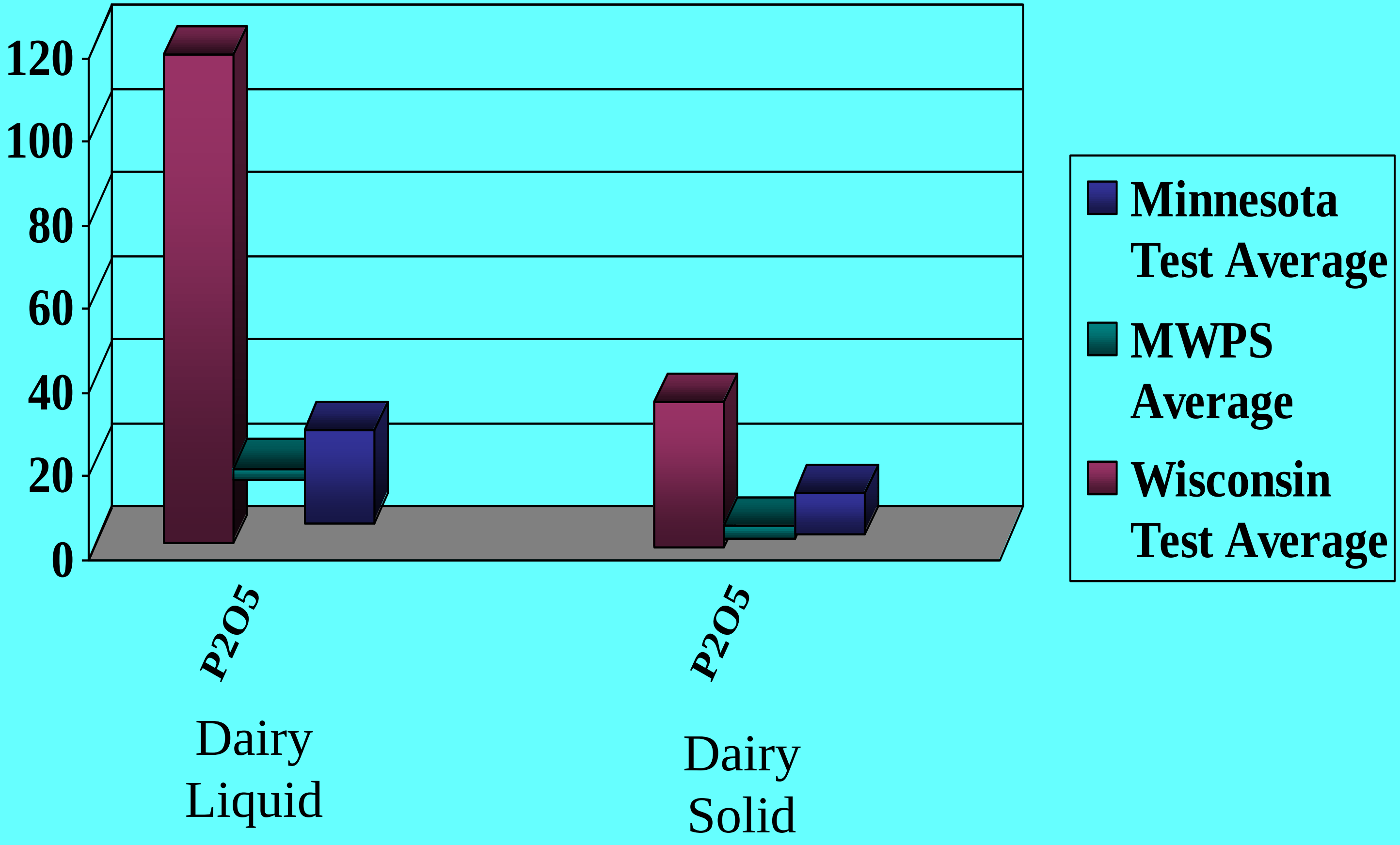
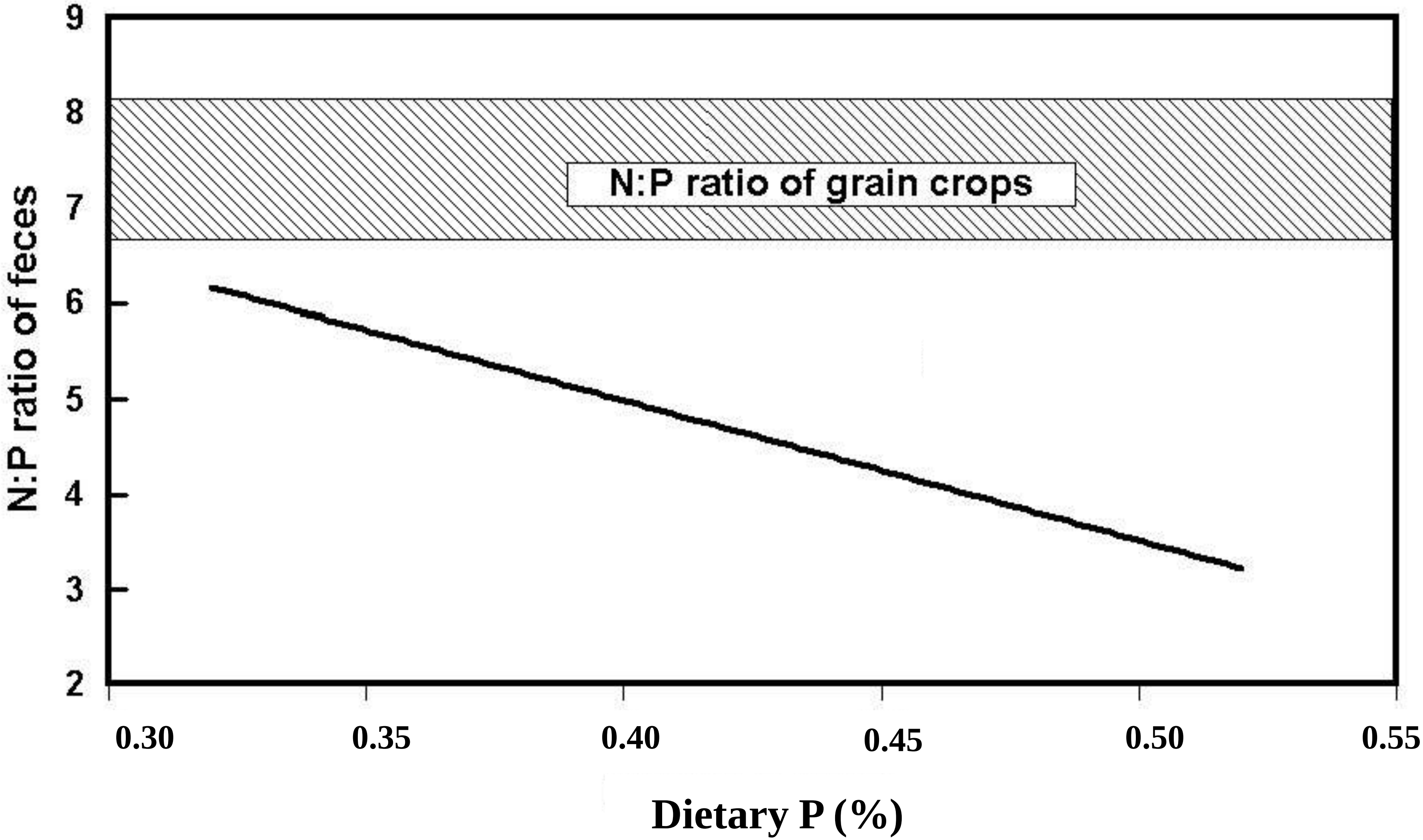
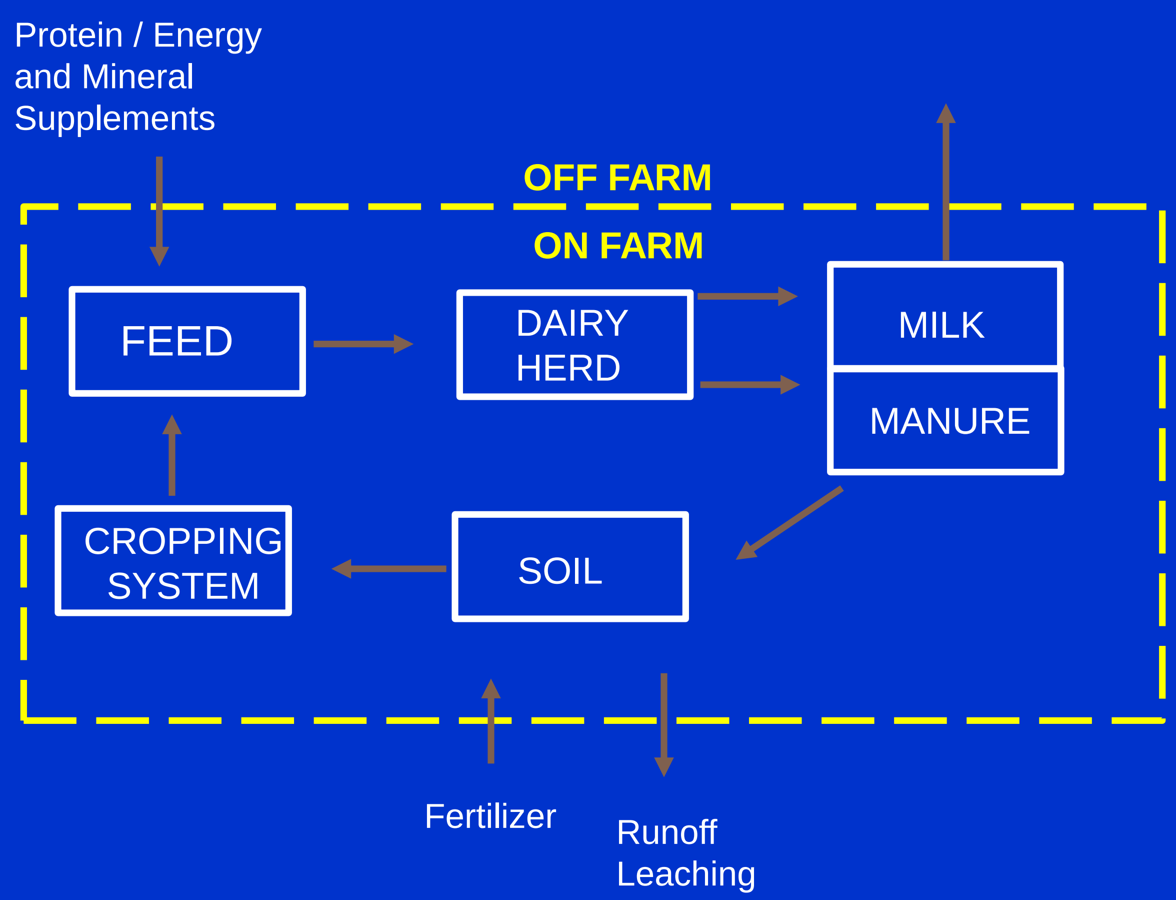


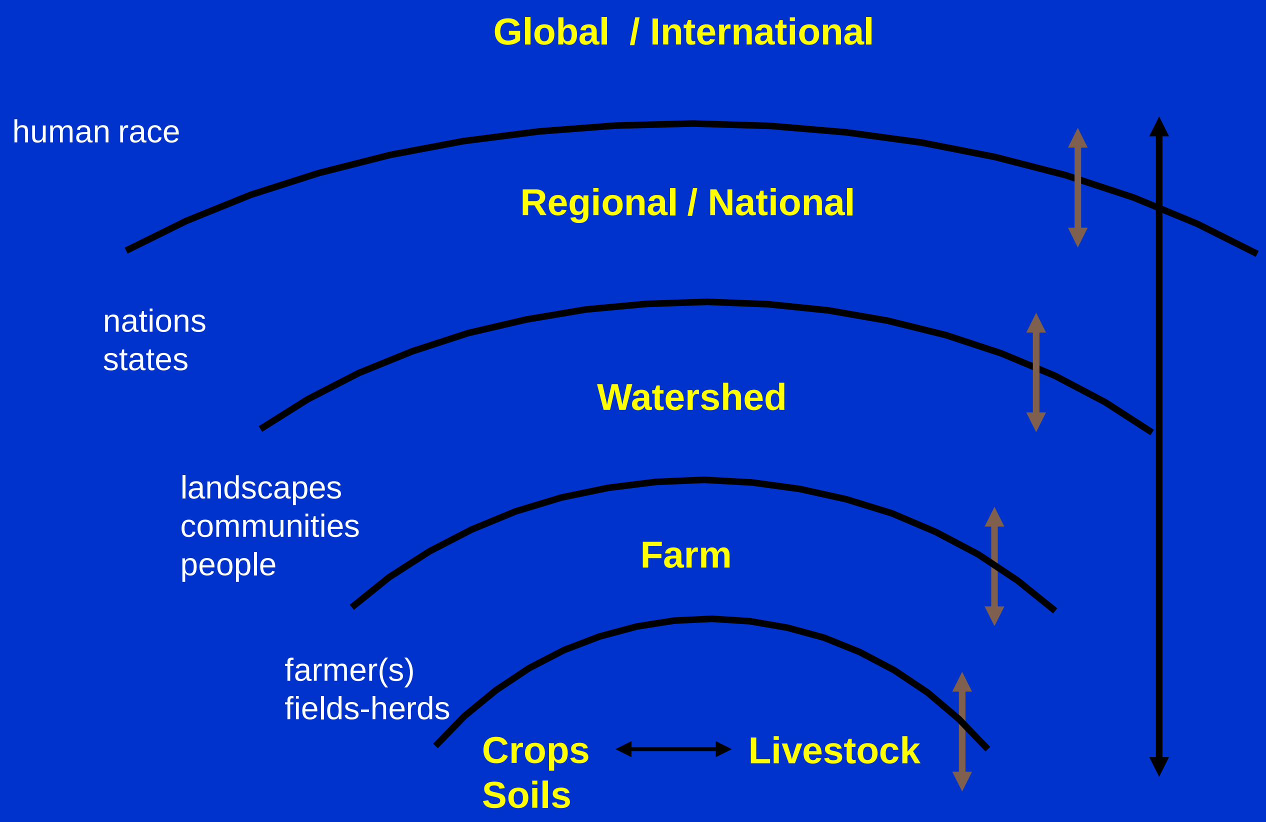
Figure 2. Dairy diet effect of N:P ratio of feces.



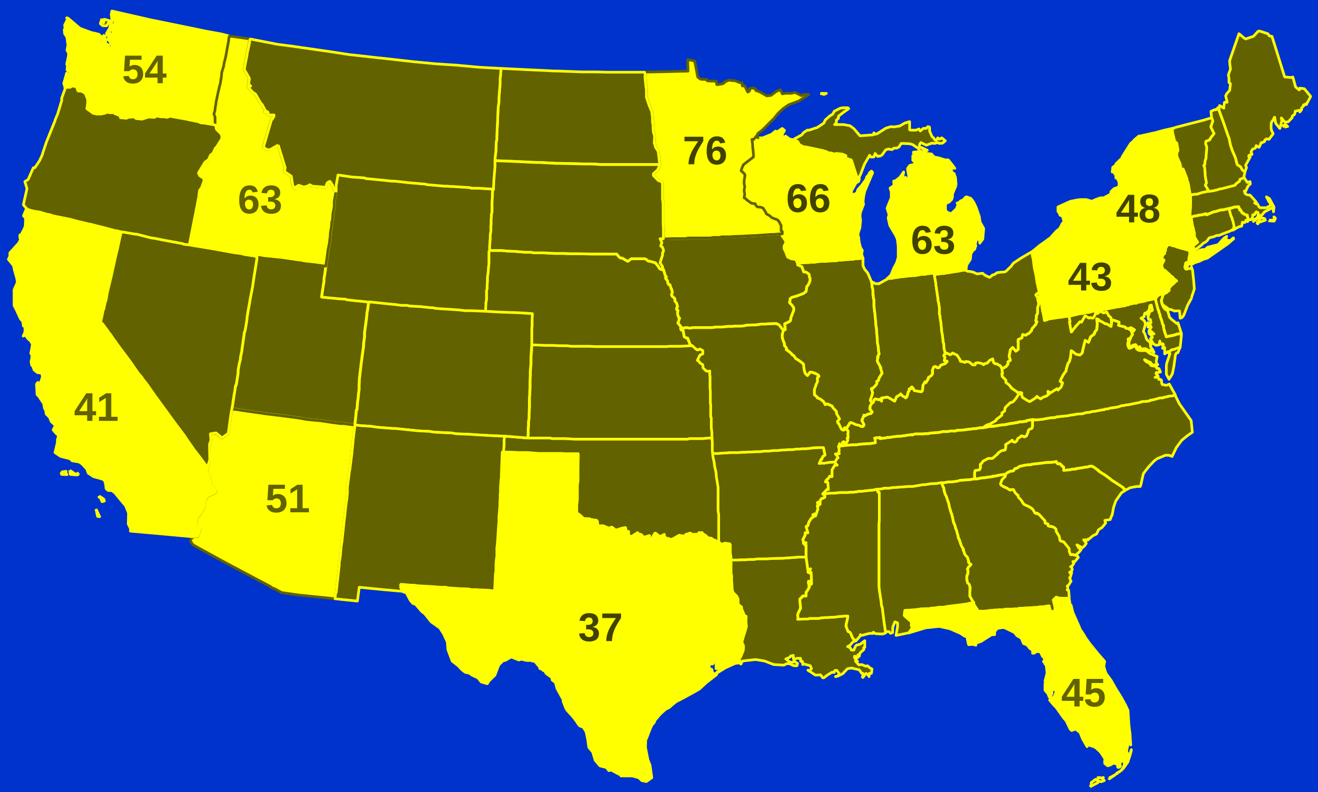
Phosphorus flow on a dairy farm



Flow of Phosphorus at Various Scales

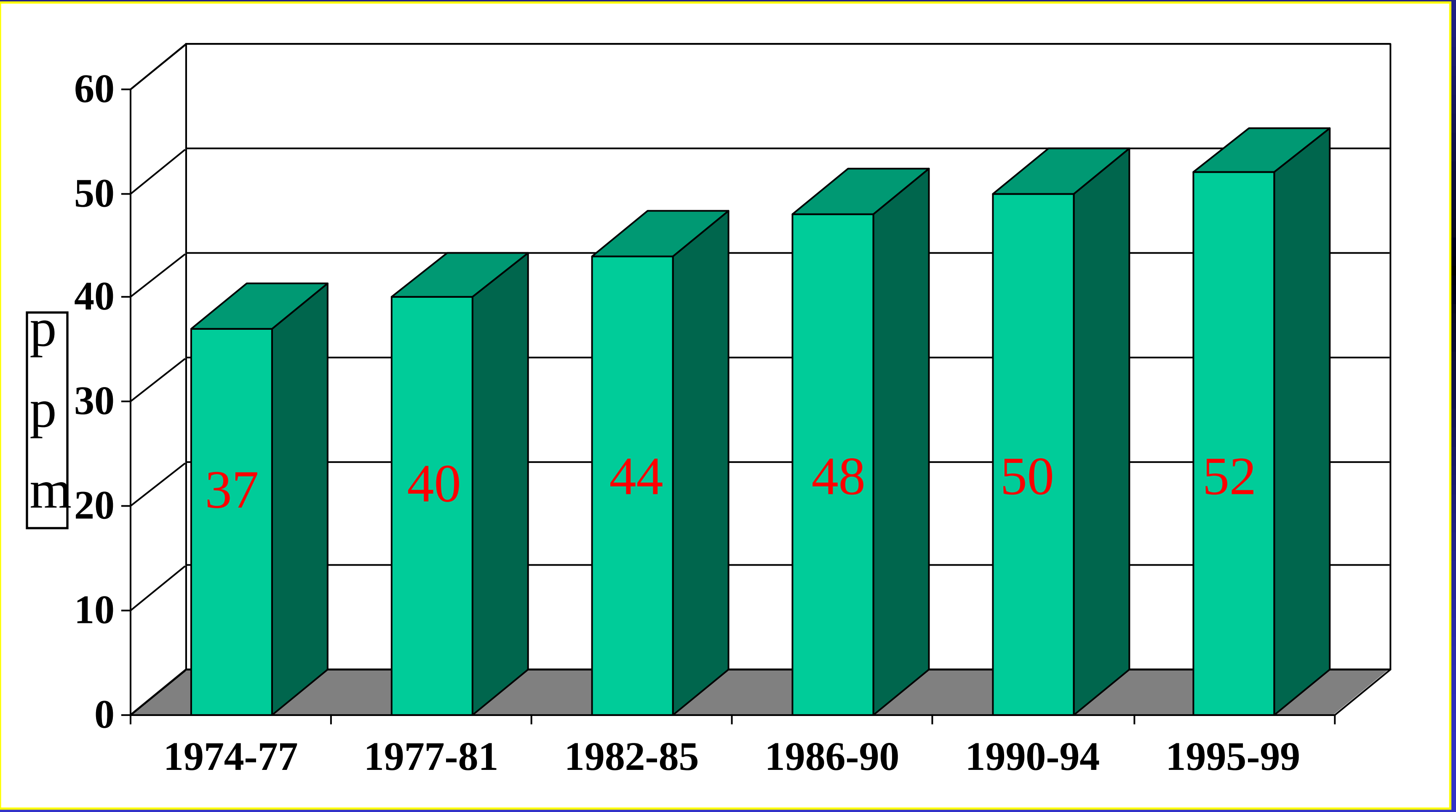


Percent of soil samples testing high or above soil test P in major dairy states, 1989.

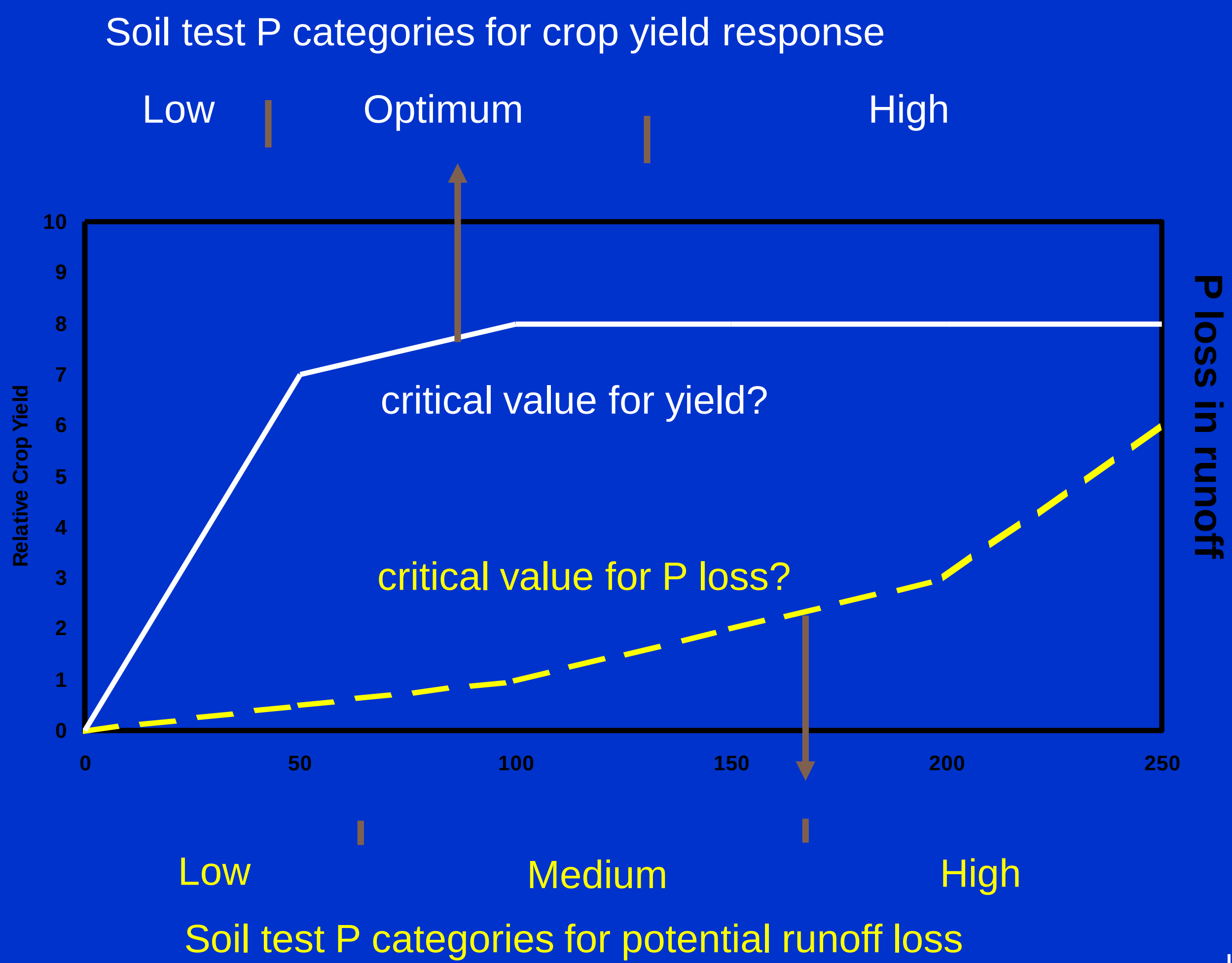


(compiled by Withers and Sharpley, 1995)

Wisconsin Soil Test P Trends: 1974-1999



Relationship between soil P, crop yield and P runoff



Kleinman, 2000

USDA-NRCS Comprehensive Nutrient Management Plans

Manure land application

Approach I   Soil specific threshold (TH) data available

(NRCS, 1999)

NRCS Guidelines: with soil specific threshold data

Soil Test P Level	Allowed P Application Rates
< ¾ TH Value	Nitrogen Based Application
≥ ¾ TH <1 ½ TH	Crop Removal
≥ 1 ½ TH < 2 TH	½ Crop Removal
≥ 2 TH	No Application

USDA-NRCS Comprehensive Nutrient Management Plans

Manure land application

Approach I   Soil specific threshold (TH) data available

Approach II   Soil test P – soil specific data not available

(NRCS, 1999)

NRCS Guidelines: without soil specific threshold data

Soil Test P Level	Allowed P Application Rates
Low	Nitrogen Based Application
Medium	Nitrogen Based Application
High	1.5 times Crop Removal
Very High	Crop Removal
Excessive	No Application

USDA-NRCS Comprehensive Nutrient Management Plans

Manure land application

Approach I — Soil specific threshold (TH) data available

Approach II — Soil test P – soil specific data not available

Approach III — P risk index

(NRCS, 1999)

HOW CAN WE CALCULATE P BALANCE FOR A FARM?

Imports	Exports
Protein Supplements	Milk
Mineral Supplements	Cull Cows and Calves
Grain / By –Products	Surplus feed
Forage	Manure?
Fertilizer	Runoff?

Annual P balance for a 100 cow diary.

P import to farm	lb	P export from farm	lb
Protein supplement	1219	Milk	1806
Dicalcium phosphate *	1627	Cull cows and calves	300
Grain	0	Surplus feed	0
Forage	0	Manure	0
Fertilizer	1181	Runoff	201
Total	4027	Total	2307

* Used to raise dietary P from 0.35 to 0.48%

Protein and Phosphorus Content of Some Common Feeds

Feed	Protein Content % of DM	Phosphorus Content % of DM	Ratio Protein : P
Bloodmeal	87.2	.26	335
Soybean meal	49.9	.68	73
Soybean (roasted)	42.8	.65	66
Corn gluten feed	25.6	.54	47
Brewer's grain	25.4	.55	46
Canola meal	40.6	1.04	39
Cottonseed	23.0	.64	36
Corn distiller's grains	25.0	.71	35
Wheat midds	18.4	.99	19
Wheat bran	17.1	1.38	12
Meat and bone meal	54.0	5.48	10

SOME LITTLE REALIZED INFORMATION ABOUT THE U.S. FEEDING STANDARD FOR PHOSPHORUS (NRC, 1988)

- NRC (1988) recommends the typical dairy cow diet contain between .34 and .41% P.
- Early lactation diets (0-3wk) should contain .48% P.
- These recommendations are about 10% higher than previous NRC (1978) recommendations.
- NRC (1988) contains 30 references on P, averaging now 32 years of age.
- Of the references cited, only 20% of the studies used lactating cows, with remaining studies utilizing laboratory animals, growing animals, or mature non-lactating animals.

Phosphorus analyses of feed samples[1] submitted to commercial laboratories and the relationship to values reported in the United States—Canadian Tables of Feed Composition (NRC, 1982)

Feedstuff	Number of Samples	Average P% (of DM)	Ratio of Sample:NRC	SD
Corn silage	8197	.23	1.05	.06
Alfalfa	4096	.30	1.38	.06
Corn grain	912	.32	1.07	.07
Ear corn	905	.29	1.07	.08
Sybean meal (50%)	148	.72	1.03	.28
Brewers grain	139	.59	1.08	.08
Distillers dried grains	114	.83	1.17	.17
Barley	115	.38	1.02	.07
Oats	38	.43	1.13	.09

[1]Berger, Anim. Feed Science and Technology 53:99, 1995.

Survey of 98 Wisconsin Dairies*

72% used forage testing

80% added supplemental P, another 12% were not sure

71% were not sure what %P is typical in rations

Of those reporting a value for ration P, the average was 0.52%

*Jackson-Smith and Powell, 2000

HOW MUCH PHOSPHORUS IS BEING FED TO DAIRY COWS IN THE UNITED STATES?

Based on a telephone survey of dairy extension specialists, consulting nutritionists, and feed industry nutritionists around the U.S., it appears that

.48% dietary phosphorus (dry basis)

is being fed to dairy cows.

WHY ARE HIGH P DIETS BEING FORMULATED AND FED?

- Provide a margin of safety
- Notion that high P diets improve reproductive performance
- Profits for those marketing mineral supplements

Milk Production Response to Dietary Phosphorus Level

Study	Dietary P (% of Diet DM)		Milk Production (lbs/day)	
	Low P	High P	Low P	High P
Kincaid et al, 1981 (20 cows/trt) (10 months)	.30	.54	61.6	66.0
Brintrup et al, 1993 (26 cows/trt) (two complete lactations)	.33	.39	55.9	53.9
Satter & Dhiman, 1997 (23 cows/trt) (12 wk mid lactation)	.39	.65	52.6	53.7
Wu et al, 1997[1] (24 cows/trt) (complete lactation)	.35	.45	65.3	63.6
Wu et al, 1998[1] (26 cows/trt) (first 27 wks of lactation)	.37	.48	86.5	84.7

[1]Unpublished studies, U.S. Dairy Forage Research Center, USDA-ARS.

Milk Production Response To Dietary Phosphorus Level (Continued)

Study	Dietary P (% of Diet DM)			Milk Production (lbs/day)		
	Very Low P	Low P	High P	Very Low P	Low P	High P
Wu et al, 1999[1] (8-9 cows/trt) (complete lactation)	.32	.41	.51	77.1	80.2	79.5
Valk and Sebek (6-8 cows/trt) (wk 17-37)	.23	.27	.33	51.2	53.0	53.8
Valk and Sebek (6-8 cows/trt) (wk 2-31)	.24	.27	.34	Deficient	81.9	80.7
Average	–	.34	.46	–	67.1	67.0

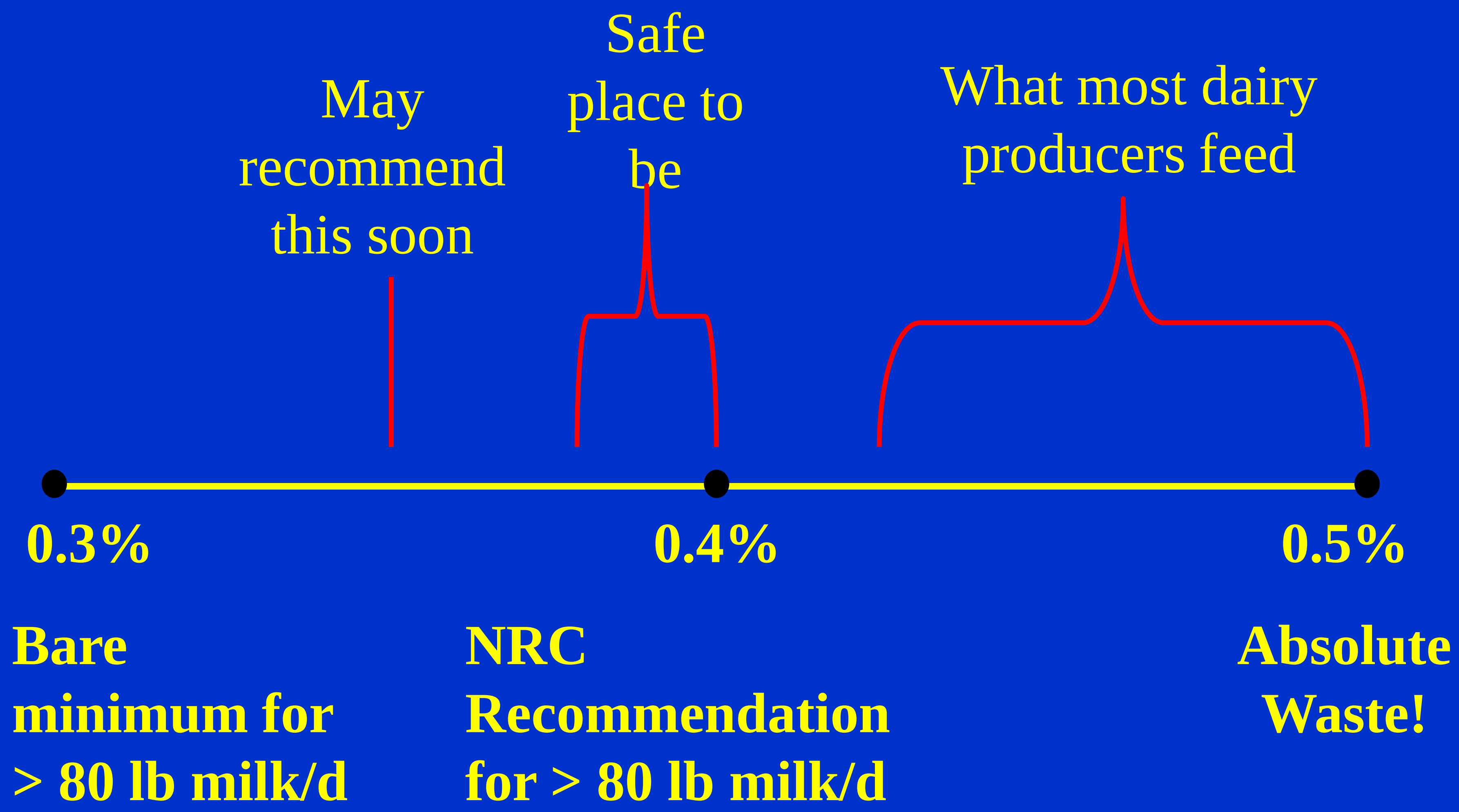
[1]Unpublished studies, U.S. Dairy Forage Research Center, USDA-ARS.

Reproductive performance of heifers and lactating cows fed a low phosphorus or high phosphorus diet (Summary of 13 trials)

	Dietary P (% of DM)	Number of animals[1]	Days to first estrus	Days open	Services per conception	Days to first AI	Pregnancy rate (%)
Cows (Lo)	.32 - .40	393	46.8	103.5	2.2	71.7	92
(Hi)	.39 - .61	392	51.6	102.1	2.0	74.3	85
Heifers (Lo)	.14 - .22	116			1.5		98
(Hi)	.32 - .36	123			1.8		94

[1]Not all of the measurements listed in this table were made in each and every trial. Thus each measurement is based on most, but not all, of the animals in column two.

WHERE ARE WE IN FEEDING PHOSPHORUS?



Annual mass phosphorus balance (tons year^{-1}) for dairy farms, New York

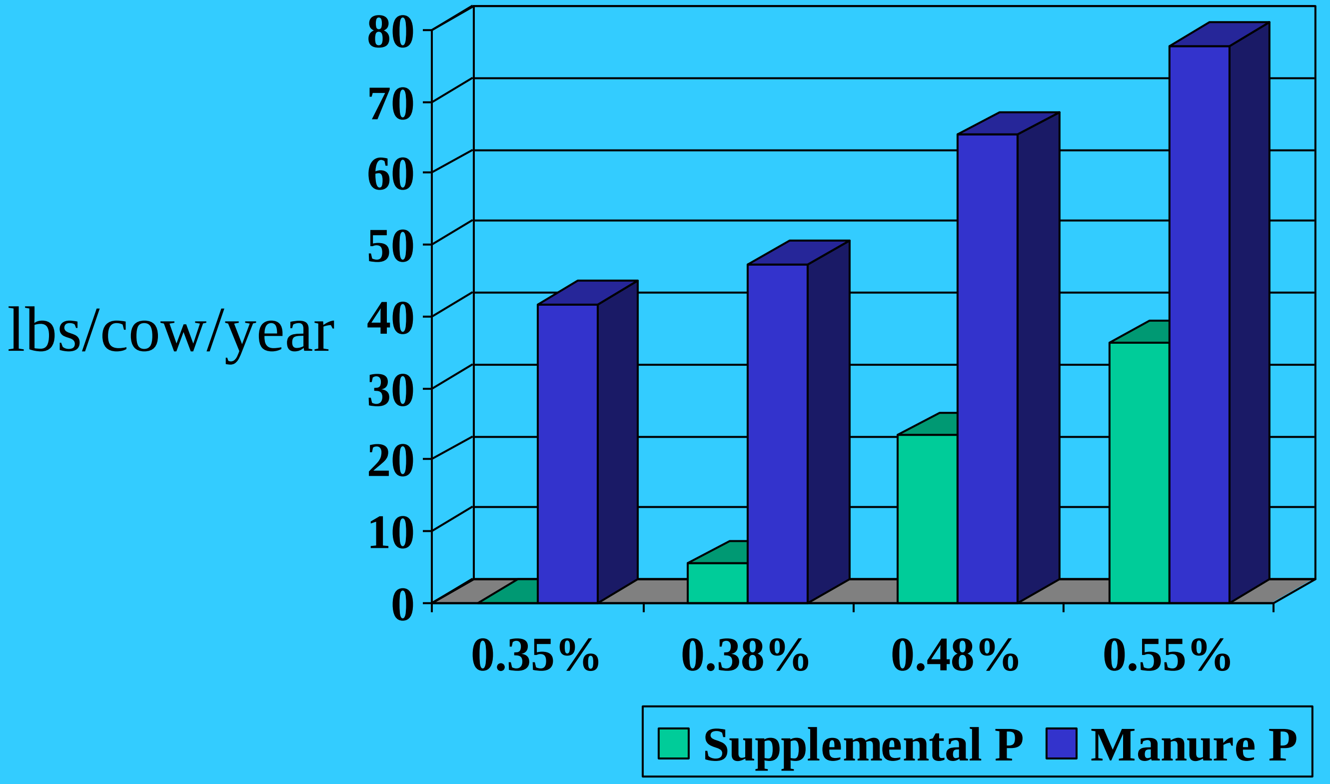
Item	Size of dairy (cows) 45	85	320	500
INPUT				
Purchased feed	1.0	1.7	8.4	14.2
Purchased fertilizer	1.2	0.9	2.0	10.0
Purchased animals	---	---	0.03	---
OUTPUT				
Milk	0.4	0.68	3.8	5.5
Meat	0.05	0.10	0.5	0.5
Crops sold	0.02	0.06	---	---
REMAINDER				
tons	1.7	1.8	6.2	18.2
%	79	68	59	75

Klausner, 1995

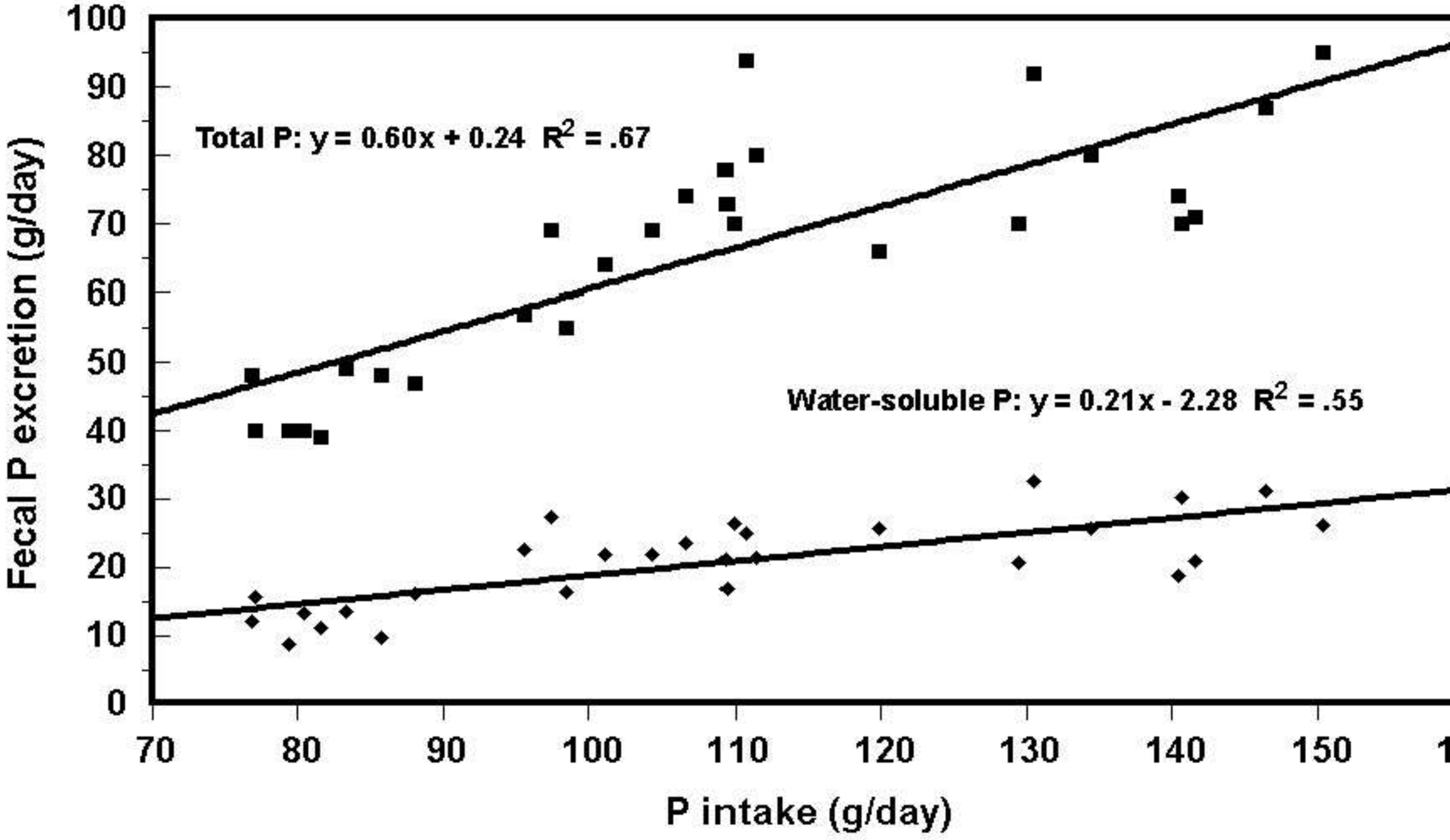
Annual P fed and excreted in feces by a lactating cow.

Dietary P level	Supplemental P	Fecal P
%	-------- lb cow^{-1}year^{-1}	---------
0.35	0	41.7
0.38	5.5	47.2
0.48	23.4	65.3
0.55	36.2	77.8

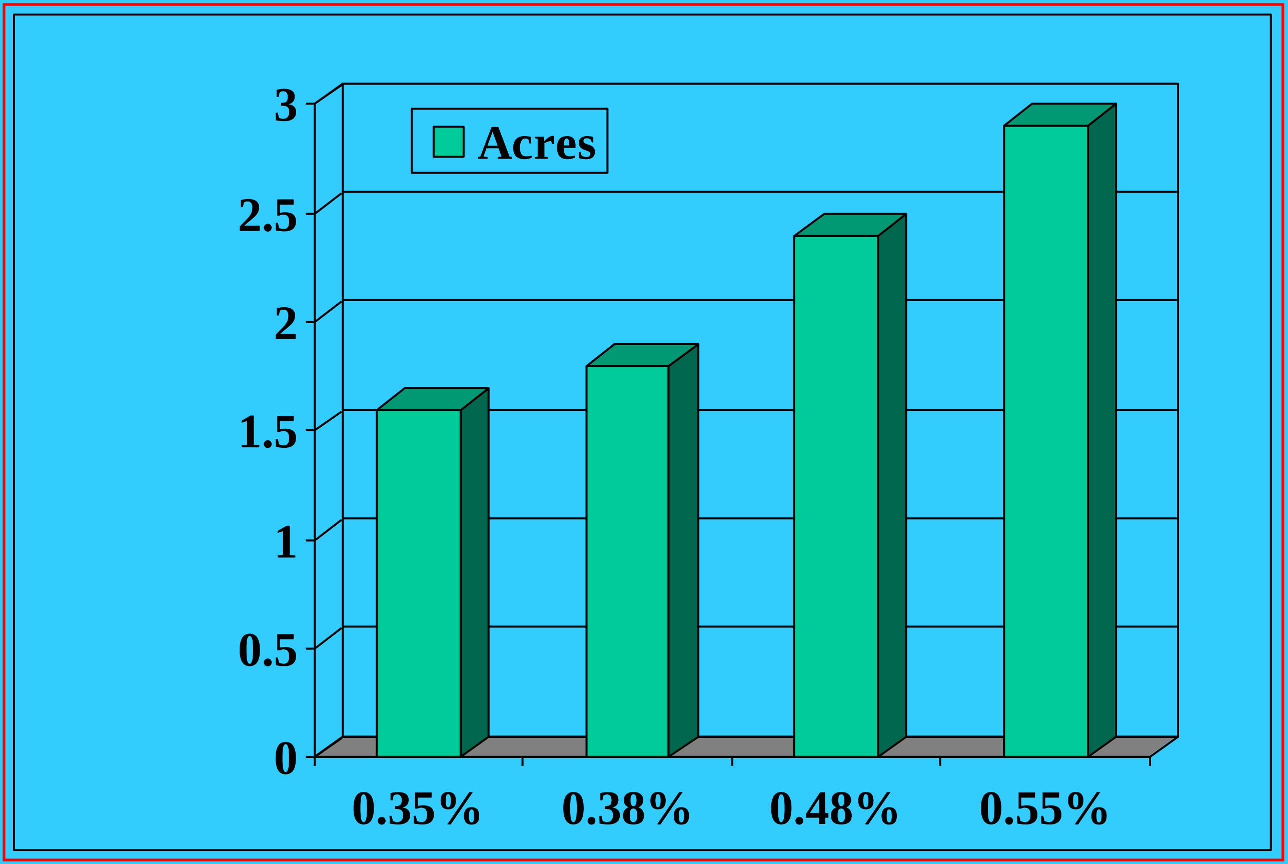
Annual P fed and excreted in feces by a lactating cow.



Dairy diet effects on total and water soluble P in manure.



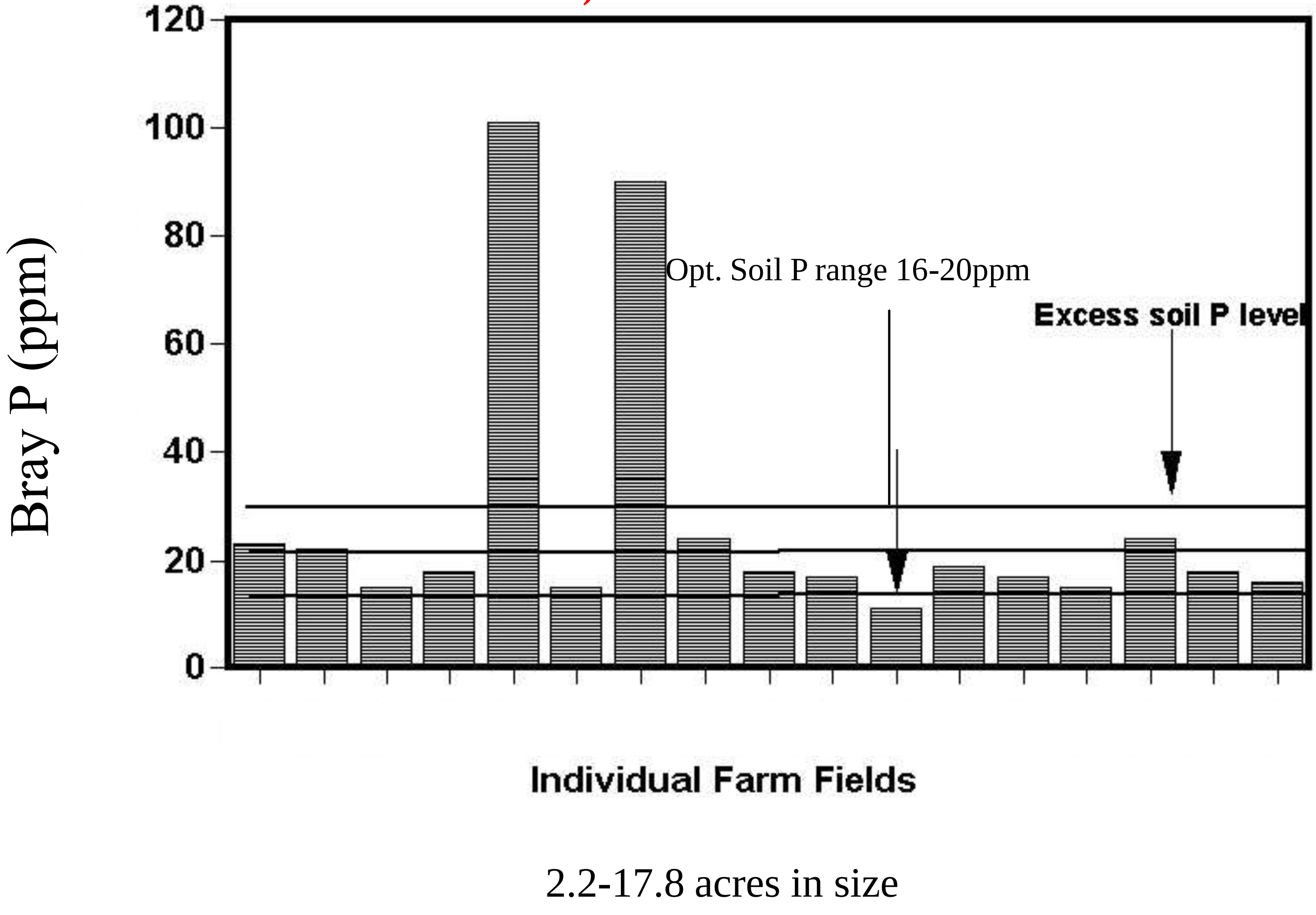
Land required for recycling fecal P from one cow fed various dietary P levels



Dietary P level

†Alfalfa, corn , soybean rotation with 27 lb P/a removal

Figure 3. Soil test P distribution on a dairy farm in Wisconsin (193 acres tillable, 170 of which test below "excessive" soil test P and could, therefore, continue to receive manure).



Effect of dairy P supplementation on a farm's ability to store soil P.

Dietary P level	Fecal P	Years to attain excessive Bray-1 P in all fields
%	lb/cow/year	
0.35	41.7	Indefinite
0.38	47.2	Indefinite
0.48	65.3	11
0.55	77.8	6

Time required to decrease soil test P

Sandy loam soil - NC

100ppm → 20ppm

16-18 years with no added P

Wisconsin example

100ppm → 20ppm

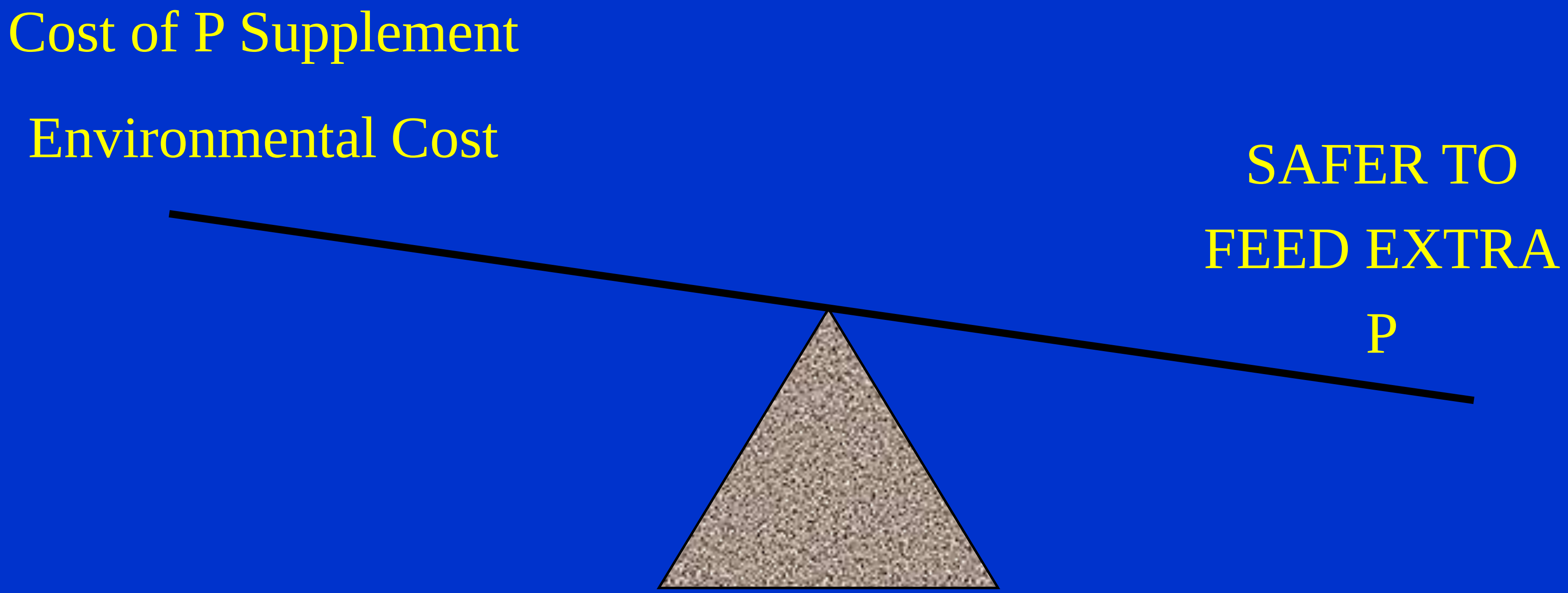
24 years with no added P

Theoretical changes in soil Bray-P levels due to the application of dairy manure from a cow fed various levels of dietary P.

Dietary P level	Manure P in excess of crop P demands	Change in Bray-1 P
%	lb/acre/year	ppm/year
0.35	– 3.0	– 0.4
0.38	– 0.1	0
0.48	10.4	1.3
0.55	17.6	2.2

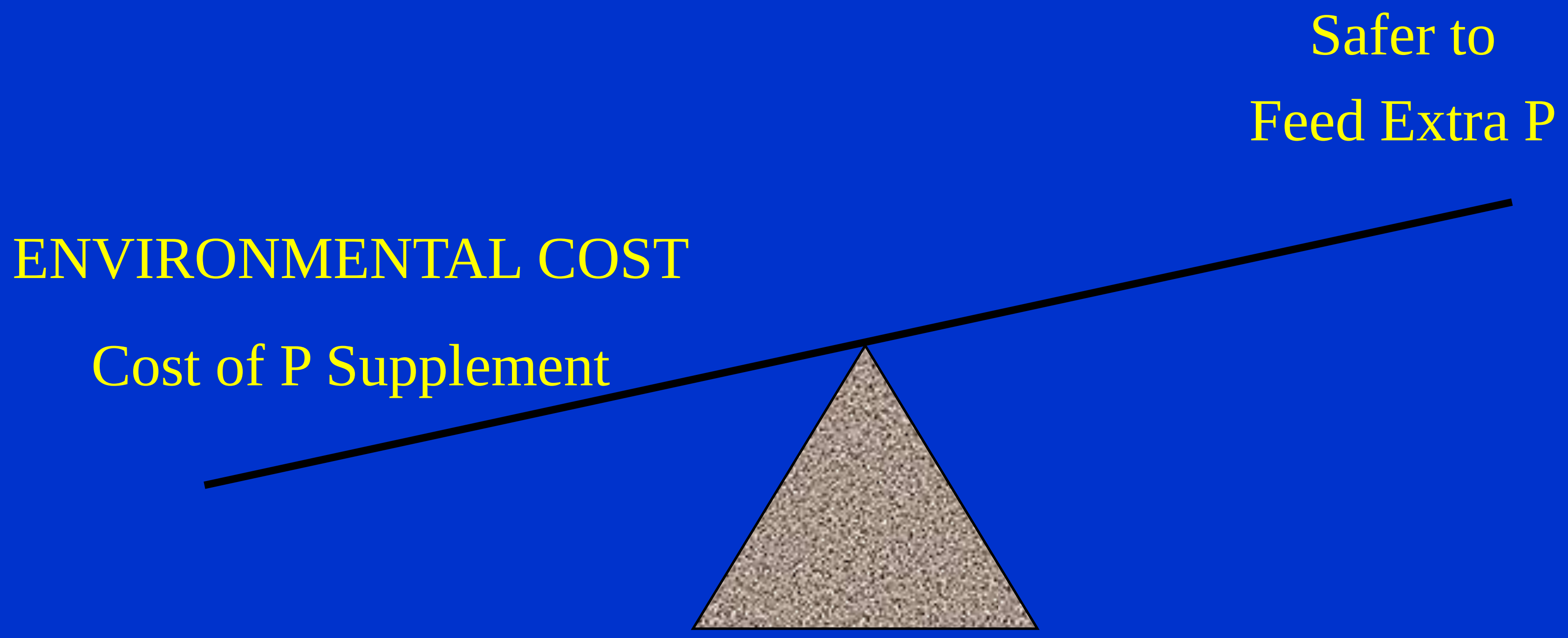
SHIFTING RISK

Yesterday



SHIFTING RISK

Tomorrow



WE OVERFEED PHOSPHORUS TO OUR DAIRY COWS!!

CAN WE REDUCE IT?

THE ANSWER IS YES, AND

- We can save money (~$100 million per year).
- We can reduce the phosphorus threat to our environment.

Summary

- The luxurious use of dietary P supplements greatly increases the land needed to recycle the manure P.
- Higher than required levels of dietary P reduces the number of years before the “P sink” is full.
- An integrated approach to improving nutrient management on dairy farms is needed.