Soil Sampling, Fertilizer Recommendations, and Economics of Fertilization

Carrie Laboski
Department of Soil Science
UW-Madison

Soil Sampling

Goals of Soil Sampling

- To collect a soil sample that is representative of a field or portion of a field
- Estimate the nutrients needed for economically profitable crop production
- Gain an understanding of nutrient variability within a field
- Monitor changes in nutrient status over time

When to Soil Sample

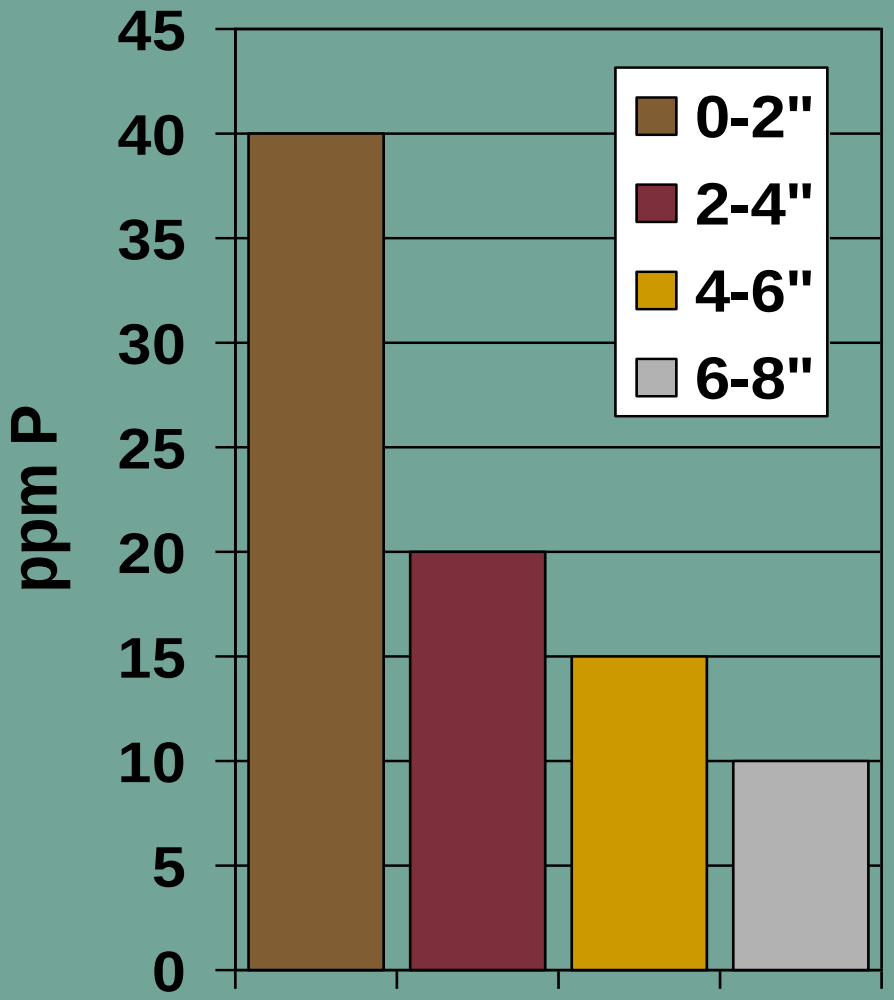
- pH, P, & K tend to be higher in spring than fall
  - Soil test levels rebound over time – movement between pools within the soil
  - Fall sampling generally provides a more conservative (larger) fertilizer recommendation
- Be consistent with timing
- Sampling frozen ground is generally not a good idea

How to Take a Soil Sample

- Tools
  - Buckets
  - Probes/augers

How to Take a Soil Sample

- Sample to plow depth or at least 6”
  - Be consistent with depth every year
  - Push aside residue
- 0 – 8” sample = 21 ppm
- 0 – 6” sample = 25 ppm
- 0 – 4” sample = 30 ppm



How to Take a Soil Sample

- Place 10-20 cores in buckets and mix thoroughly for a composite sample
- Place ~ 2 cups of soil in sample bag
  - Bag should be labeled with your name, field id, and sample number (eg. Laboski – Field A – Sample 3)
- Mark location of sample on an aerial map or drawing
- Fill out soil info. sheet

Where to Soil Sample

- Types of sampling schemes
  - Whole field
  - Grid
  - Zone
- Scheme used is determined by:
  - Expected fertilizer management approach
  - Sampling history
  - Existing fertility level

Whole Field

- Used where a single fertilizer recommendation will be used in a field
- Conventional sampling
- Plus – relatively cheap
- Minus – no info. about nutrient variability

Whole Field – Sampling Intensity

Field characteristics	Field size (acres)	Suggested number of samples
Fields tested > 4 years ago; *or* Fields testing in responsive range	All fields	1 sample/ 5 acres
Non-responsive fields tested ≤ 4 years ago	5 – 10	2 samples/ field
	11 – 25	3 samples/ field
	26 – 40	4 samples/ field
	41 – 60	5 samples/ field
	61 – 80	6 samples/ field
	81 - 100	7 samples/ field

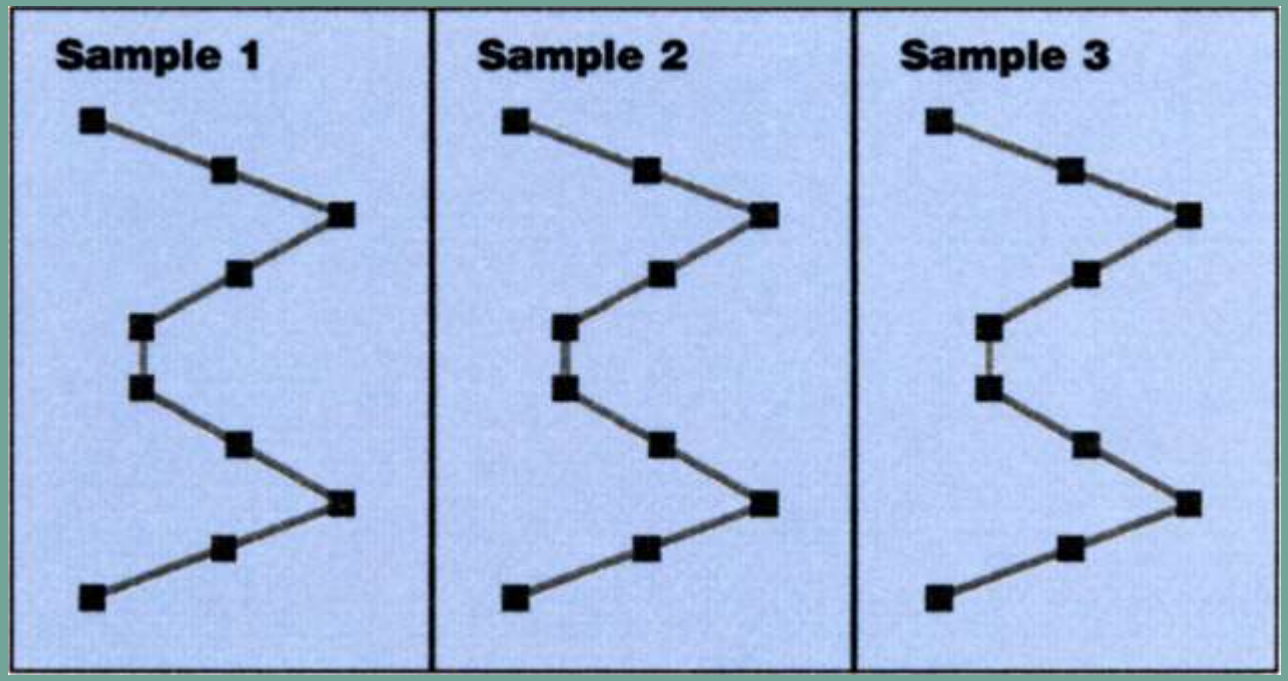
- Responsive range is where either soil test P or K are in the high (H) category or lower
- Non-responsive range is where both soil test P & K are in the very high (VH) or excessively high (EH) category

Whole Field

- Avoid sampling unusual areas:
  - Dead furrows or back furrows
  - Lime, sludge, or manure piles
  - Near fences or roads
  - Rows where fertilizer has been banded
  - Eroded knolls/ low spots
- If distinctive area is large enough, sample separately

Whole Field

- Sampling pattern for 15 acre field with past soil tests in responsive range



- Each sample should be composed of at least 10 cores

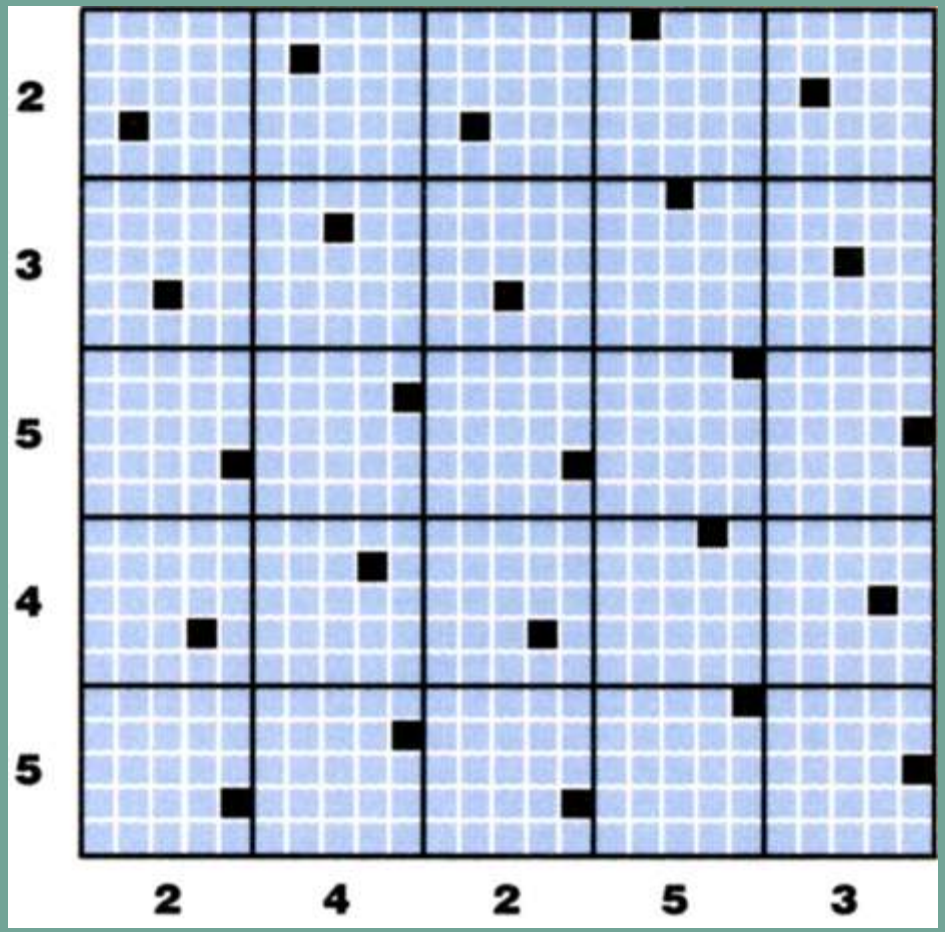
Grid

- Used where nutrients will be applied variably
- Can be useful if purchase/rent new ground and past history not well known
- Plus – good assessment of nutrient variability
- Minus – expensive

Grid

- Unaligned systematic grid point method
  - 300’ (2.1 acre) grid – if both P & K are in non-responsive categories (VH & EH)
  - 200’ (0.92 acre) grid – if either P or K are in responsive categories (below H)

Grid



- Sample locations have GPS coordinates
- Sample consists of at least 10 cores composited within a 10’ radius of grid point

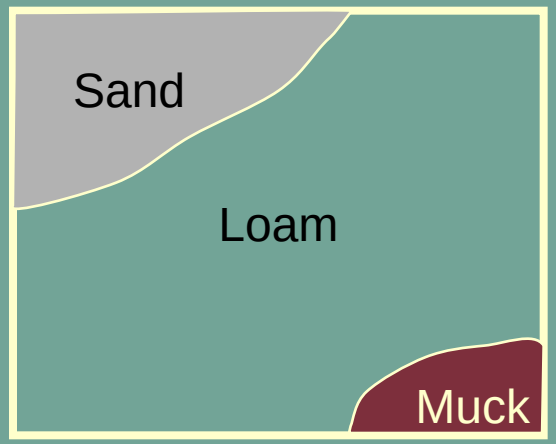
Zone

- Used where management may be different across a field
- Zone borders and/or sampling points can be georeferenced
- Plus/Minus
  - Provides an assessment of variability better than whole field, not as good as grid
  - Cost Effective

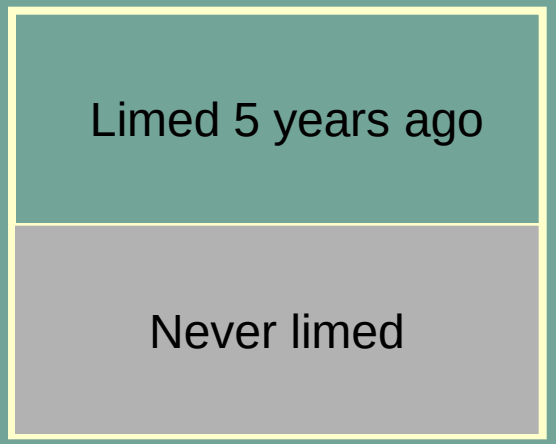
Zone

- Zone delineation – based on knowledge of the field
  - Soil and/or yield maps
  - Topography/elevation map
  - Past history
  - Nutrient maps from previous grid sampling
- Follow whole field sampling intensity guidelines, considering the zone a field

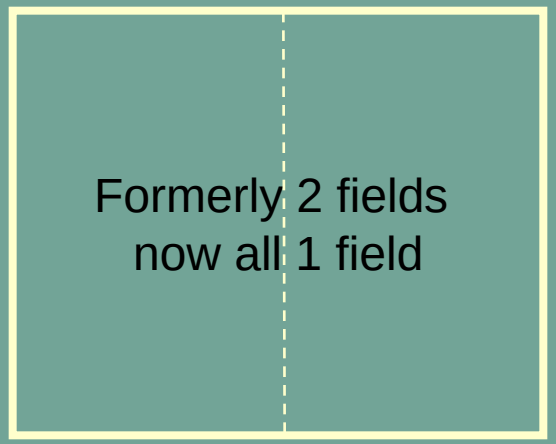
Zone Delineation



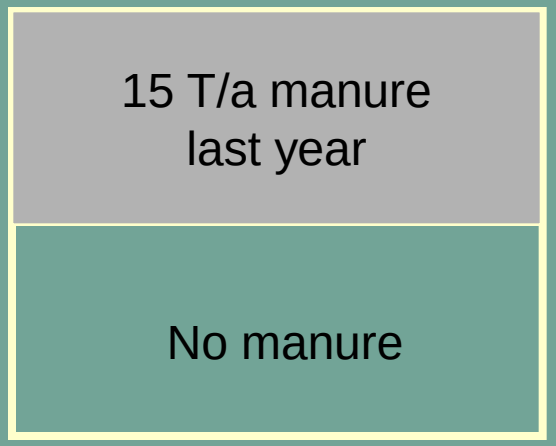
3 zones



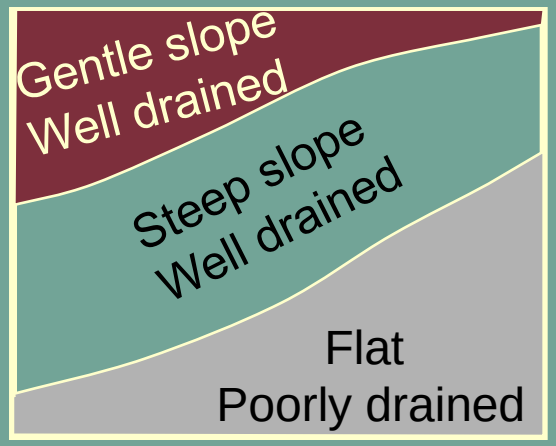
2 zones



2 zones



2 zones



3 zones

Contour Strip Fields

- If strips are ≥ 5 acres, sample each strip separately
  - Use whole field sampling intensity guidelines
- If strips are < 5 acres and cropping & management histories are identical:
  - Combine cores from 2 – 3 strips
- If grid sampling a contour striped field, make sure sampling locations are in each strip

Fields requiring special sampling procedures

- Chisel plowing and offset disking
  - ¾ of tillage depth
- Till-plant and ridge till
  - Sample ridges to 6” and between rows (furrows) to 4”
- No-till
  - 0-2” for pH
  - 0-6” for nutrients

Soil Sampling

- See UWEX Factsheet A2100 for additional details

Soil Testing

Sample Analysis

- Samples must be analyzed by a Wisconsin DATCP certified lab
- Analyses must follow specified procedures
- UW recommendations

DATCP Certified labs

- UW Soil and Plant Analysis Lab - Madison
- UW Soil and Forage Analysis Lab - Marshfield
- A & L Great Lakes, Inc. – Fort Wayne
- Ag Source Cooperative Services
- Dairyland Laboratories
- Mowers Soil Testing Plus, Inc.
- Rock River Laboratory

- List current as of October 2004

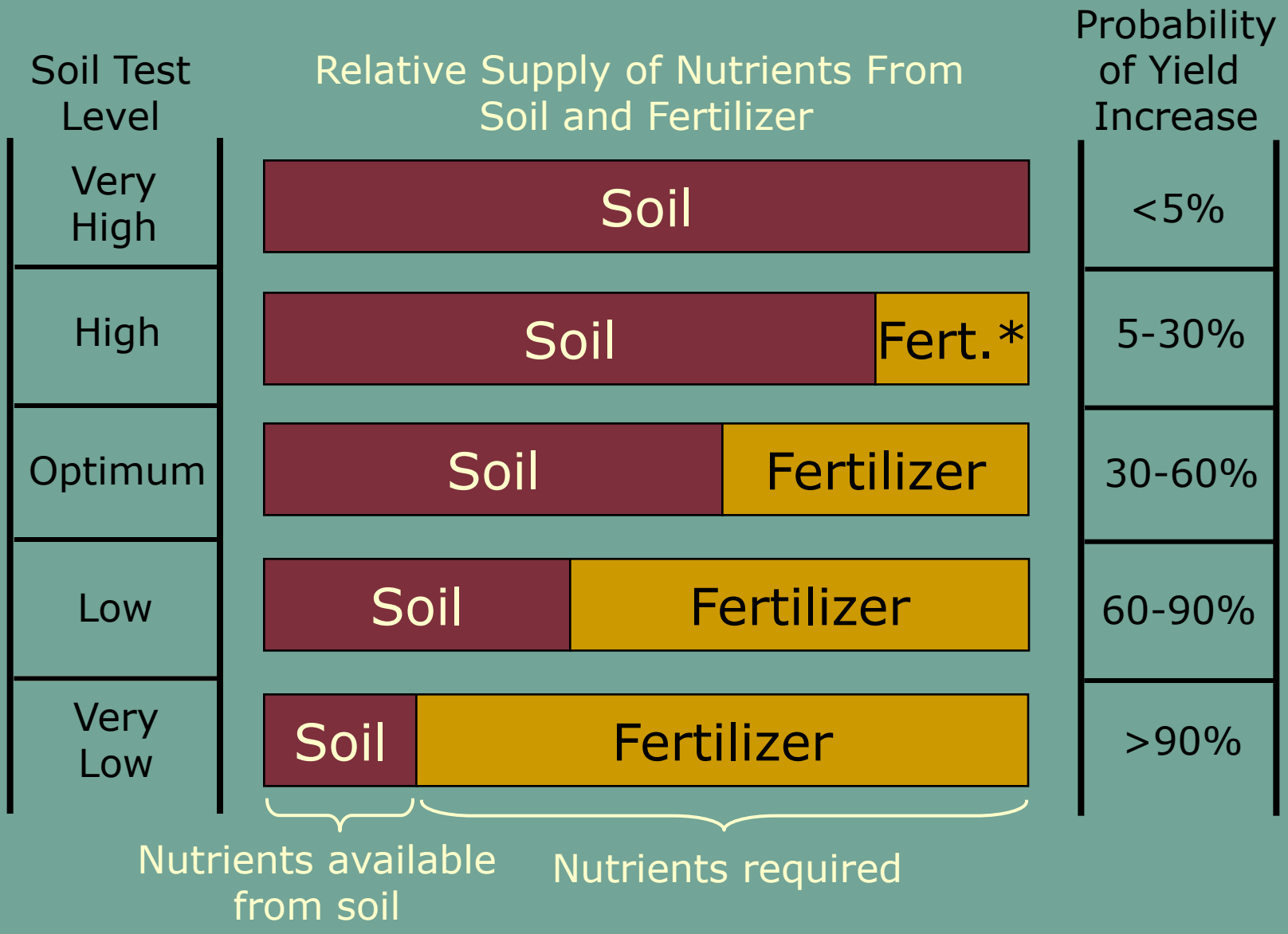
Specified Procedures

- Details of procedures can be found at:
  http://uwlab.soils.wisc.edu/procedures.htm

Recommendations

- Recommendations for nutrients must be consistent with UW recommendations
  - UWEX Bulletin A2809
- UW recommendations
  - Best estimate to optimize economic return
  - Not developed as an environmental standard
  - Based on research on Wisconsin soils

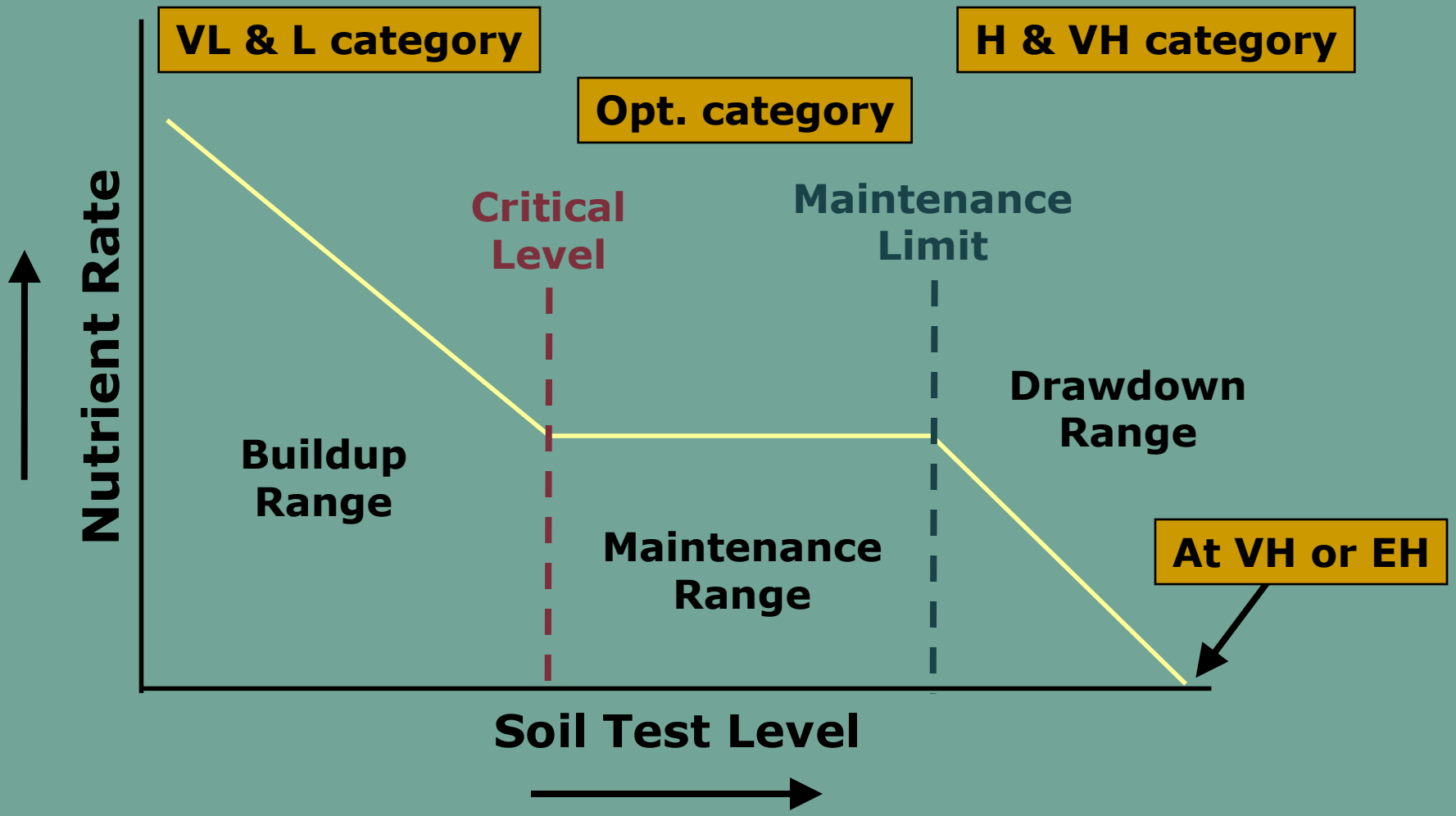
Soil Test Interpretation Categories



Adapted from Havlin et al.,1999 using WI interpretations

* Fertilizers used at high soil test levels are for starter or maintenance purposes

Relationship Between P & K Soil Test and Fertilizer Recommendation



Relationship Between P & K Soil Test and Fertilizer Recommendation

Soil Test Category	Fertilizer Recommendation Amount
Very Low, Low	Crop removal +
Optimum	Crop removal
High, Very High	½ or ¼ Crop removal
Excessively High	None

UW Recommendations – P & K

- Recommendations in A2809 consider:
  - Crop demand (Table 4, p 17)
  - Soil type (Table 10, p 25-32)
    - Get subsoil group code
  - Soil test level (Tables 5 & 6, p 19-20)
    - Determines interpretation range, probability of response
  - Yield goal
    - Determine relative nutrient need

N Recommendations

	--- Sands/loamy sands ---		----- Other soils yield potential -----	
OM	Irrigated	Non-irrigated	Low/Med	High/Very High
%	---------- lb N/a ----------			
< 2	200	120	150	180
2-9.9	160	110	120	160
10-20	120	100	90	120
> 20	80	80	80	80

- **Subtract legume & manure N credits**
- Does not include ≤ 20 lb N/a in starter
  - Any starter N > 20 lb N/a should be subtracted from rate in the table
- If > 50% residue cover after planting, increase rate by 30 lb N/a
- Optimum N rate similar for good or bad year – not a function of yield goal

Legume N Credits

Crop	Sandy Soils Regrowth < 8”	Sandy Soils Regrowth > 8”	Other Soils Regrowth < 8”	Other Soils Regrowth > 8”
	---------- lb/A ----------			
Alfalfa, > 70% stand	100	140	150	190
Alfalfa, 30-70% stand	70	110	120	160
Alfalfa, < 30% stand	40	80	90	130
Alfalfa, seeding	0	60	0	100
Red Clover/Birdsfoot Trefoil, > 70%	80	110	120	150
Red Clover/Birdsfoot Trefoil, 30-70%	50	90	90	130
Red Clover/Birdsfoot Trefoil, < 30%	30	60	70	100
Vetsch	40	110	90	160
Soybean	0		40	
Beans (snap/dry), peas	0		20	

Notes: Forage Legume N Credits

- Credits not affected by:
  - Time of killing
  - Method of killing
  - Tillage
- 2nd year credits
  - 50 lb N/a for good or fair stands
  - No credit on sands and loamy sands

- Stand Assessment

Assessment	Stand	Alfalfa
	%	Plants/ft^2
Good	> 70	> 4
Fair	30 – 70	1.5 – 4
Poor	< 30	< 1.5

Lime Recommendations

- Based on:
  - Soil pH, OM, buffer pH, target pH
- Recommendation based on crop with greatest target pH
- Lime recommended when:
  - soil pH < target pH – 0.2
- Report indicates T/a of 60-69 and 80-89 lime needed to reach target pH

Lime Recommendations

Rotation 1	
Crop	Target pH
Corn	6.0
Oats	5.8
Alfalfa	6.8
Alfalfa	6.8
Lime to 6.8 if pH is ≤ 6.6	

Rotation 2	
Crop	Target pH
Corn	6.0
Oats	5.8
Red Clover	6.3
Red Clover	6.3
Lime to 6.3 if pH is ≤ 6.1	

Reading a Soil Test Report

SOIL TEST REPORT

Samples Analyzed By:
UW Soil & Plant Analysis Lab
5711 Mineral Point Road
Madison, WI 53705

COOPERATIVE EXTENSION
University of Wisconsin-Extension
University of Wisconsin-Madison
Soils Department, Madison, WI

Results also available on-line at http://uwlab.soils.wisc.edu/reports
lab number: 12345 access code: 12345

This Report is for:
Bucky Badger

LAB #: 12345

County	Account No.
Dane	556996

Date Received	Date Processed
7/30/2003	8/27/2003

Slope	Acres	Plow Depth
2%	3	7"

Soil Name
Antigo

Field Name
1

NUTRIENT RECOMMENDATIONS

Cropping Sequence	Yield Goal	Crop Nutrient Need			Fertilizer Credit				Nutrients to Apply		
		N	P2O5	K2O	Legume N	Manure N	P2O5	K2O	N	P2O5	K2O
	per acre	lbs/a			lbs/a	lbs/a			lbs/a		
Corn, grain	131-150 bu	150	25	70	0	0	0	0	150	25	70
Oat	61-90 bu	60	15	90	0	0	0	0	60	15	90
Alfalfa	4.6-5.5 tons	0	65	290	0	0	0	0	0	65	290
Alfalfa	4.6-5.5 tons	0	65	290	0	0	0	0	0	65	290

The lime required for this rotation to reach pH 6.8 is 4 T/a of 60-69 lime or 3 T/a of 80-89 lime.

ADDITIONAL INFORMATION

If lime has been applied in the last two years, more lime may not be needed due to incomplete reaction.

Year 1: If corn harvested for silage instead of grain add extra 30 lbs P2O5 per acre and 90 lbs K2O per acre to next crop.

If barley or oats are underseeded with a legume forage, reduce nitrogen by 50%.

Starter fertilizer (e.g. 10+20+20 lbs N+P2O5+K2O/a) is advisable for row crops on soils slow to warm in the spring.

A soil nitrate test may better estimate actual corn needs.

If conservation tillage leaves more than 50% residue cover when corn follows after corn, add an additional 30 N lbs/a.

If alfalfa will be maintained for more than three years, increase recommended K2O by 20% each year.

TEST INTERPRETATION

Cropping Sequence | Very Low | Low | Optimum | High | Very High | Excessive

Corn, grain
PPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPP
KKKKKKKKKKKKKKKKKKKKKKK

Oat
PPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPP
KKKKKKKKKKKKKKKKKKKKKKKKKKKKKKKKKK

Alfalfa
PPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPP
KKKKKKKKKKKKK

Alfalfa
PPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPP
KKKKKKKKKKKKK

Rotation pH
XXXXXXXXXXXXXXXXXXXXXX

LABORATORY ANALYSIS

Sample Identification	Soil pH	O.M %	Phosphorus ppm	Potassium ppm	Calcium ppm	Magnesium ppm	Estimated CEC	Boron ppm	Manganese ppm	Zinc ppm	Sulfate-Sulfur ppm	Sulfur Avail. Index	Texture Code	Sample Density	Buffer Code
1	6.0	1.9	21	86									2	1.00	5.0
Adjusted Averages	6.0	1.9	21	86											

Example

- Plano soil
- Crop to be grown is corn (180 bu/a)
- Previous crop = soybean, next crop = soybean
- No manure applied within past 5 years
- Tillage = chisel/disk
- Soil test info.
  - P = 25 ppm
  - K = 85 ppm
  - pH = 6.0
  - Buffer pH = 6.1
  - OM = 3.0%

Example

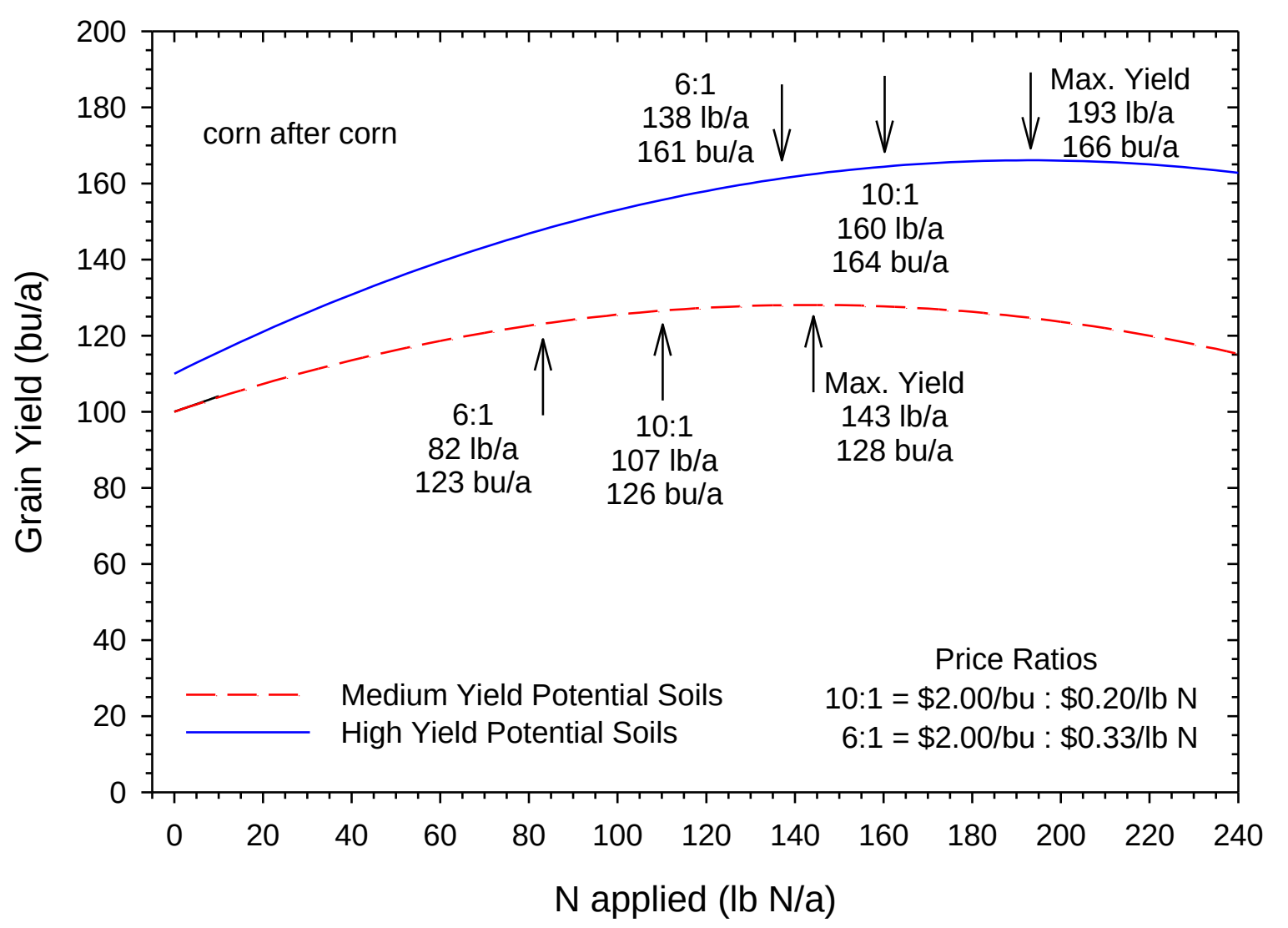
Subsoil group =	
Yield potential =	
P & K demand level (Table 4) =	
Target pH (Table 4) =	
Soil test P category (Table 5) =	
Soil test K category (Table 6) =	
P recommendation (Tables 14 & 19)	
K recommendation (Tables 14 & 19)	
N recommendation (Tables 20 & 25)	
Lime recommendation (Table 9 & p. 6)	

Example

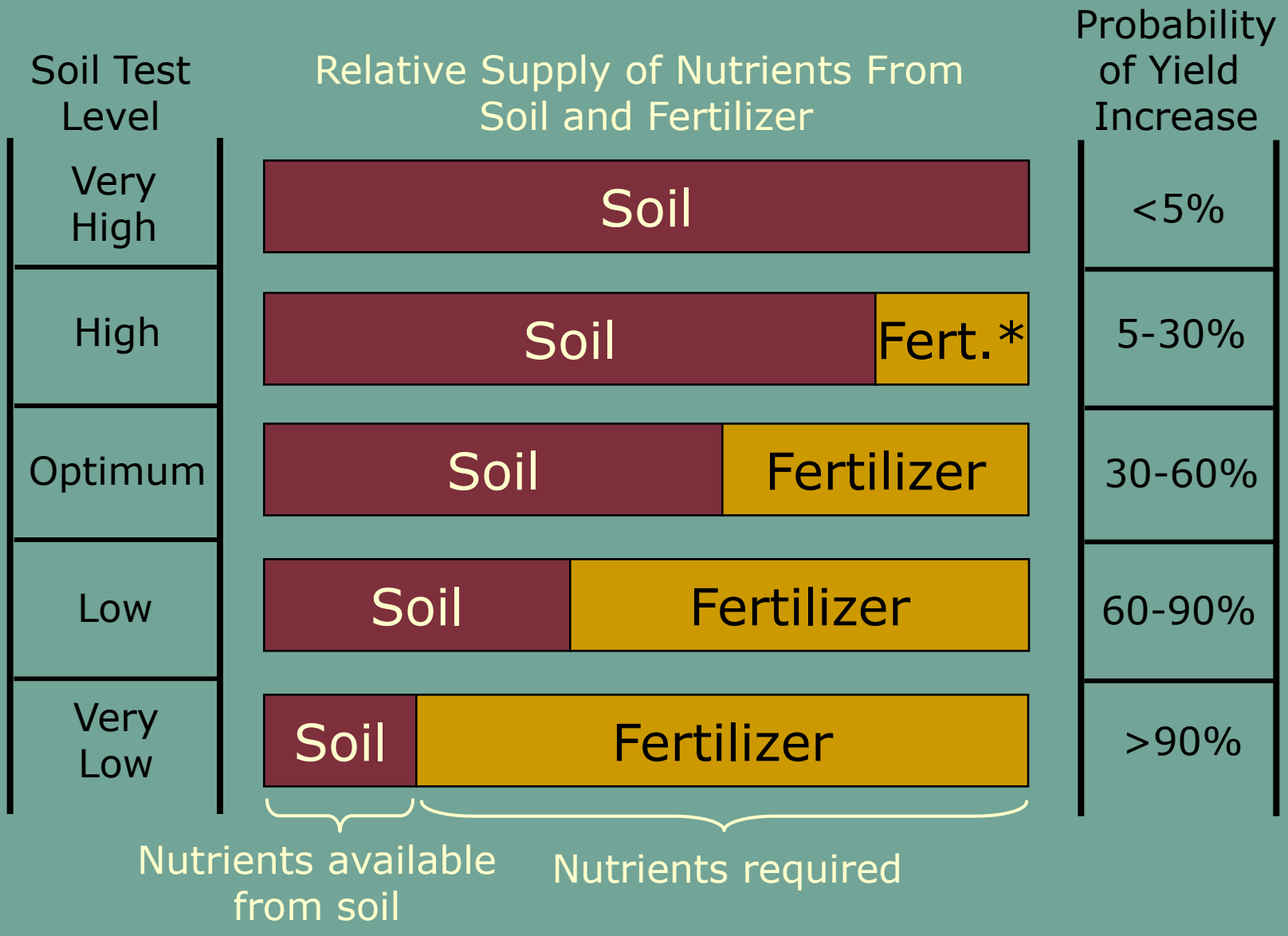
Subsoil group =	B
Yield potential =	1
P & K demand level (Table 4) =	1
Target pH (Table 4) =	6.3
Soil test P category (Table 5) =	H
Soil test K category (Table 6) =	L
P recommendation (Tables 14 & 19)	0 lb/a
K recommendation (Tables 14 & 19)	80 lb/a
N recommendation (Tables 20 & 25)	120 lb/a
Lime recommendation (Table 9 & p. 6)	2.4 T/a of 60-69 lime

Economics of Fertilization

Law of Diminishing Returns



Soil Test Interpretation Categories



Adapted from Havlin et al.,1999 using WI interpretations

* Fertilizers used at high soil test levels are for starter or maintenance purposes

Prioritizing Fertilizer Applications for Immobile Nutrients

- Soil test to determine nutrient need
- Fully credit nutrients in manure
- Apply nutrients to lowest testing fields first
- Apply some nutrients to all fields likely to respond to nutrient application
- Depending on fertilizer supply and cost, defer nutrient applications on soils testing high or above
- Consider overall nutrient needs and the budget available for purchases

7 “Fail-Safe” Steps for Maximizing Fertilizer Returns with Limited Resources

1. Soil test to determine need
2. Lime adequately
3. Grow best crop possible
4. Use “right” rate
5. Take nutrient credits
6. Maximize efficiency /avoid losses
7. Avoid unnecessary additions

Top-Seven “Fail-Safe” Steps for Maximizing Fertilizer Returns with Limited Resources

7. Avoid unnecessary additions
6. Maximize efficiency /avoid losses
5. Take nutrient credits
4. Use “right” rate
3. Grow best crop possible
2. Lime adequately
1. Soil test to determine need

UW Department of Soil Science

UW Extension

College of Agricultural & Life Sciences
University of Wisconsin-Madison

http://www.soils.wisc.edu/extension