Soil sampling and interpretation

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Multnomah Conservation Districts
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Why do chemical analysis of soils?

- Establish baseline nutrient status
- Determine application rates
- Assess pH and need for liming
- Measure changes over time
- Avoid excess nutrient application

A Guide to Collecting Soil Samples
for Farms and Gardens

M. Fery and E. Murphy

EC 628
Revised September 2013

A Guide to Collecting Soil Samples
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Without a soil analysis, it's nearly impossible to determine what a soil needs in order to be productive. Laboratory soil analyses (soil tests) provide information on your soil's available nutrient-supplying capacity. This information helps you select the correct kind and amount of fertilizer and liming material, which helps you develop and maintain more productive soil and increased crop production.

Recommendations in this publication are based on the results of fertilizer experiments, soil surveys, and results obtained by farmers.

Why should I collect a soil sample?

Reasons for soil sampling include the following:

- Establish baseline soil nutrient status for new landowners
- Measure change in soil nutrient status over time
- Document soil nutrient management for certification requirements
- Determine nutrient application recommendations prior to planting
- Assess pH and the need for liming
- Avoid excessive nutrient applications or soluble salt accumulation
- Develop a plan for possible variable-rate fertilizing within a field

When should I collect my soil sample?

For perennial crops such as orchards, tree plantations, alfalfa, grass seed, and permanent pasture, the most important time to have the soil analyzed is before planting, so that necessary nutrients can be mixed into the soil. This analysis is especially important in acidic soils, which are likely to need liming. Apply lime and mix it with the soil several months before planting (for example, in the fall for spring planting), since it reacts slowly with the soil. Following establishment, then:

- For pastures and legumes, test soils every 3 years after planting.
- For Christmas trees, established fruit and nut trees, berries, and grapes, use annual foliar tissue analysis instead of soil

This publication is not intended to be a guide for obtaining soil samples for environmental testing.

Melissa Fery and Elizabeth Murphy, instructors, Extension Small Farms Program, Oregon State University

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How often to test soil

- **Preplant for perennial crops, very important.**
- Some nutrients (P and K) and lime application work best if incorporated into top 6 inches of soil (preplant)
- Usually, soil testing every 4 years or so is sufficient

Soil probe

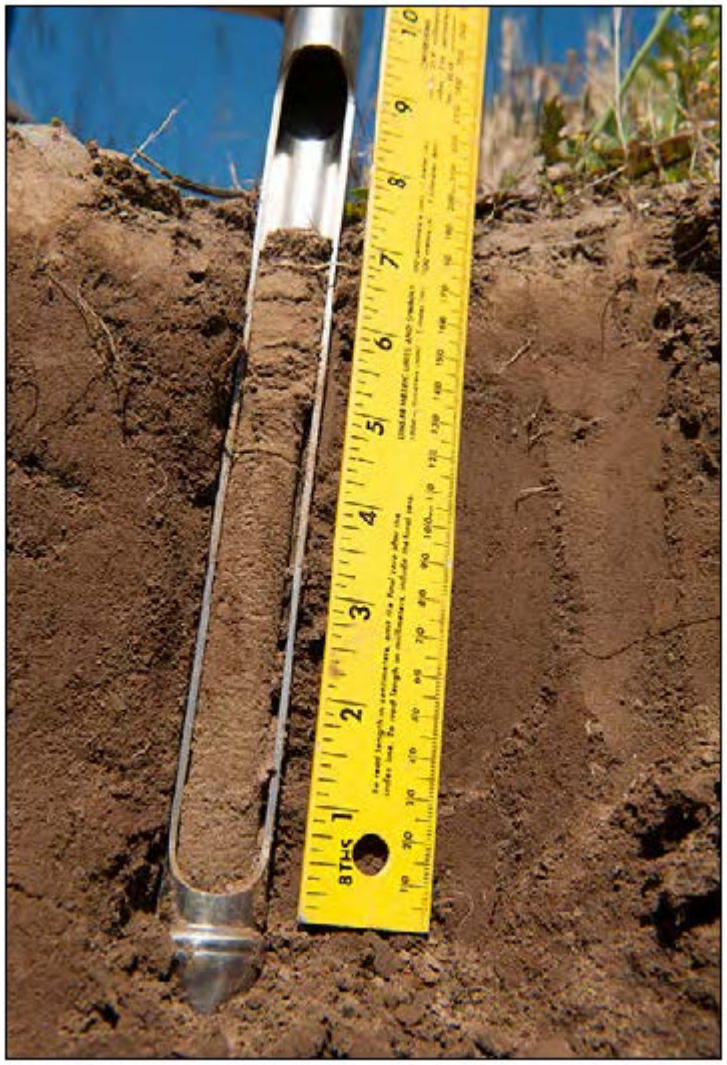


Photo: OSU Extension

- Collect same amount of soil from each depth
- Known sampling depth
- Easy to clean out between samples

Soil sampling depth

- Usually tillage depth (6 to 8 inches)

Use a garden shovel? (No!!)

- Depth unknown
- More soil from top than from bottom of hole
- May be zinc plated

Photo: Virginia Tech

Figure 3. Soil sampling tools.

- Goal is to obtain uniform sample to prescribed depth
- Nutrients usually higher near soil surface
- When soil is rocky, a “sharpshooter” (at left) may be your best tool

Determine management units

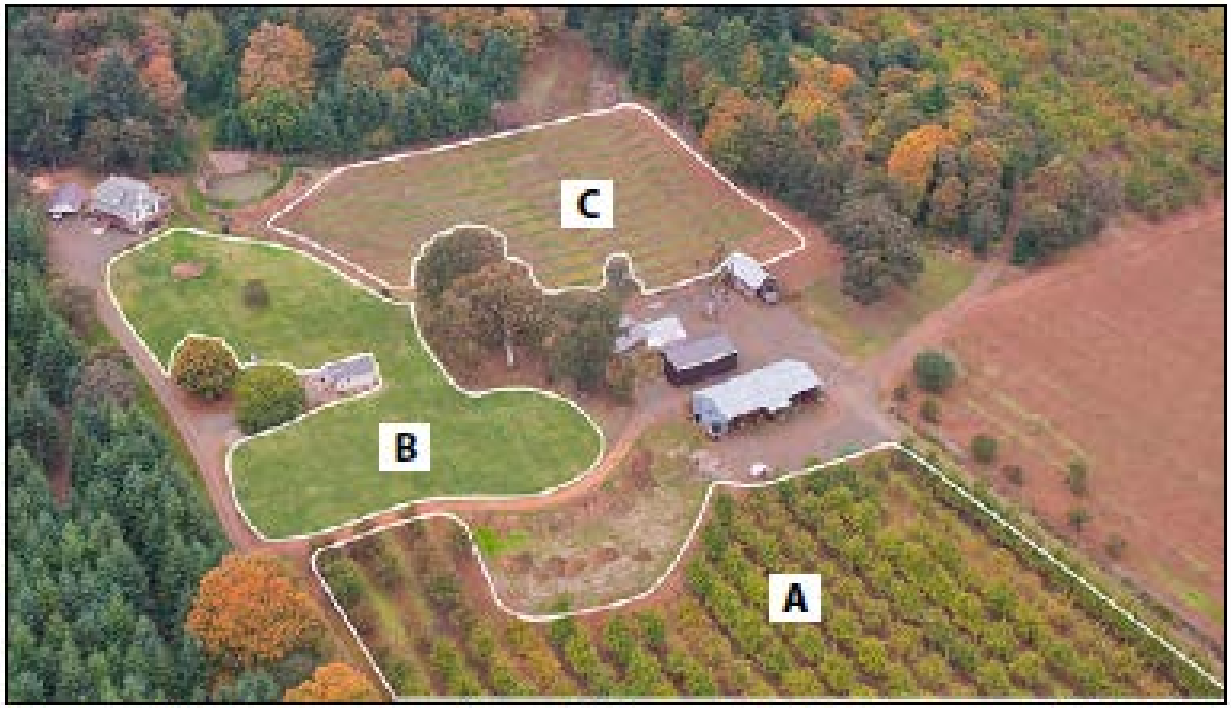


Figure 1. Collect a separate soil sample from each of the three areas (A, B, and C).

Collect a representative composite soil sample of 15+ cores

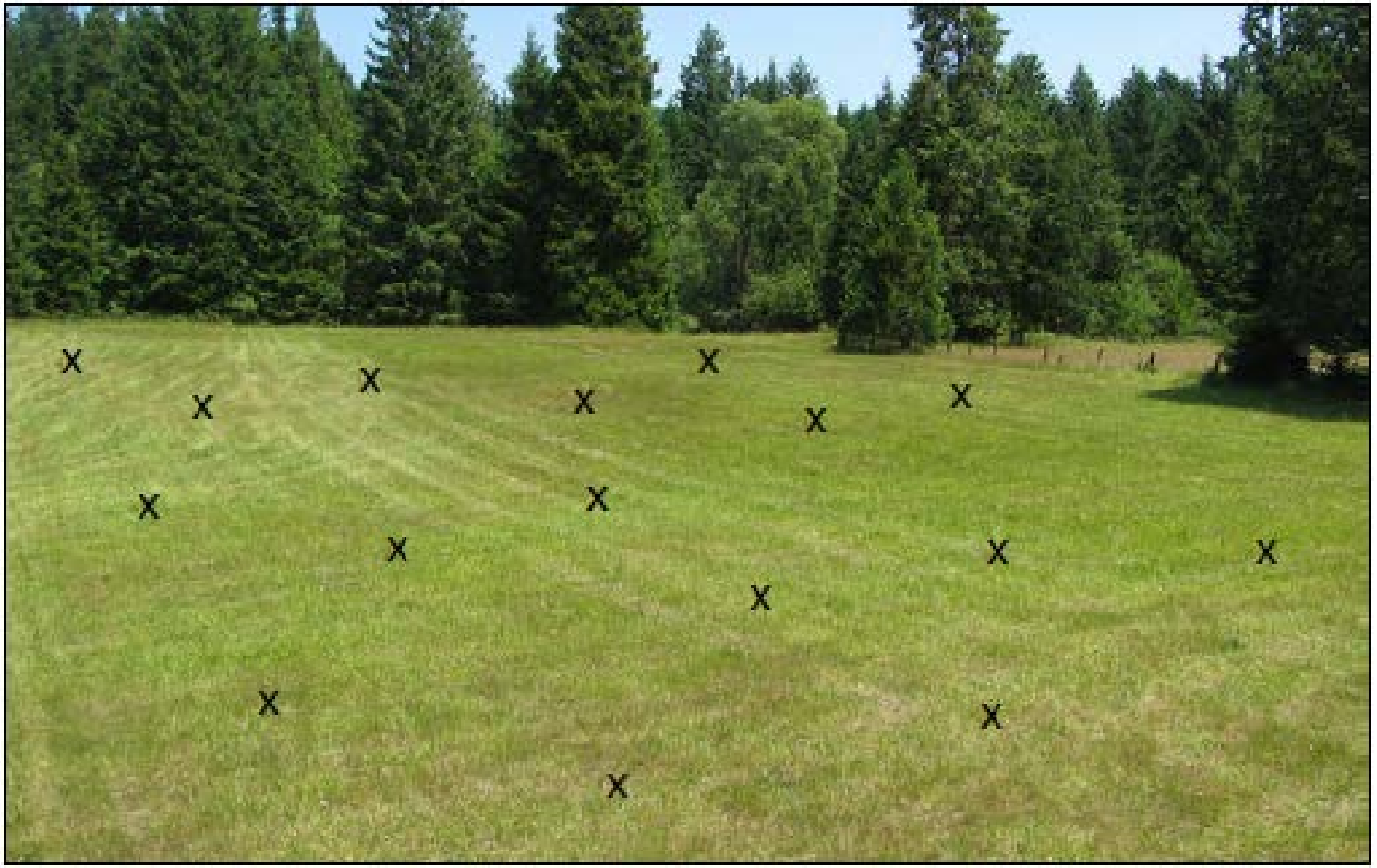
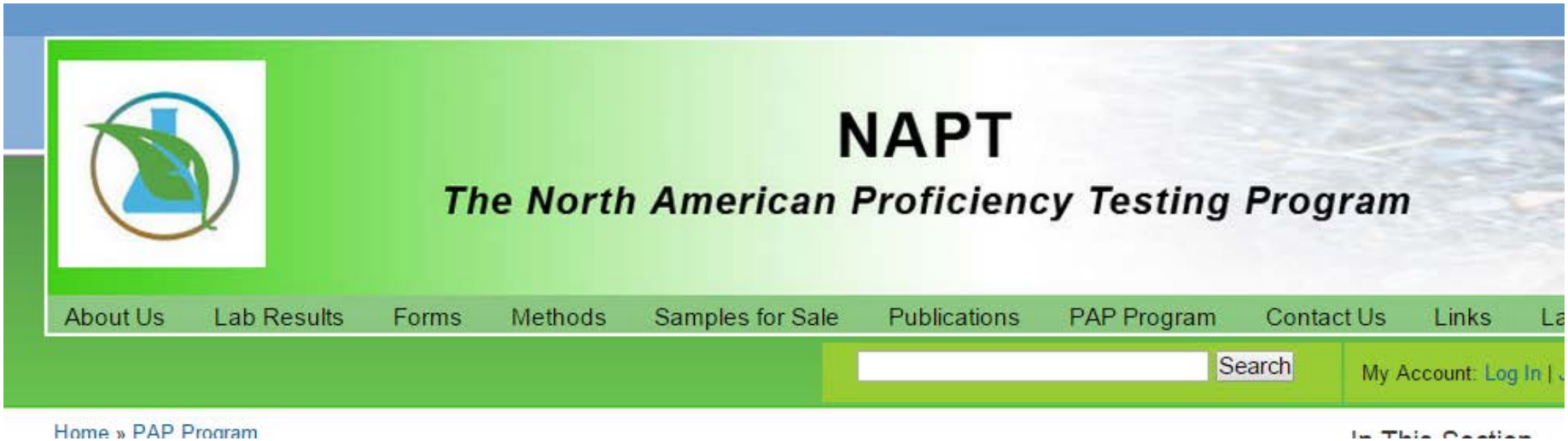


Figure 2. Take 15 to 20 subsamples within one sampling area.

Sample where the crop will be planted



- http://www.naptprogram.org/pap
- Voluntary soil testing quality control program supervised by Soil Science Society of America
- About 10 labs in West were “certified” in 2014
- Based on annual performance in accurate analysis of “double-blind” soil samples
- Must use NAPT-PAP lab when sampling under cost-share agreement with NRCS for nutrient management

Suggestions for best value from soil testing

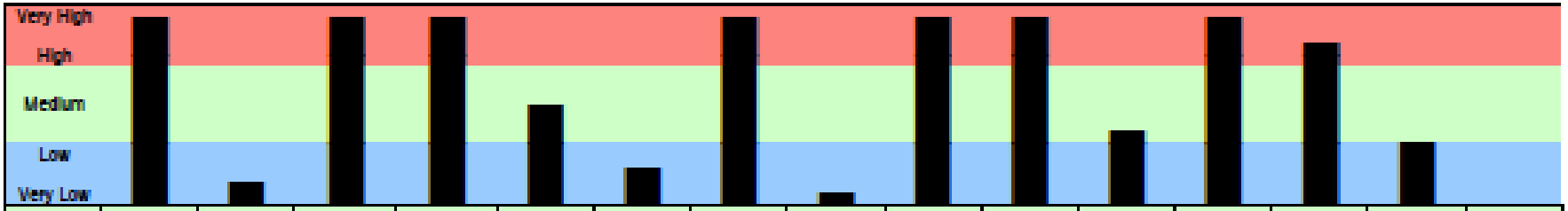
- Review OSU fertilizer/nutrient guide before you sample. Note sampling depth(s) and recommended soil tests
- Keep soil sampling method consistent (depth, month)
- Send samples to labs that are certified by North American Proficiency Testing Program http://www.naptprogram.org/pap/labs
- Keep records field by field in a database

How are soil tests interpreted?

Commercial soil test report

Graphical Soil Analysis Report

DATE OF REPORT: 09/20/13 LAB NO: 58535 SAMPLE ID: L PAGE: 1



Analyte	Organic Matter %	Nitrogen NO_3-N ppm	Phosphorus Weak Bray ppm	Phosphorus $NaHCO_3$-P ppm	Potassium K ppm	Magnesium Mg ppm	Calcium Ca ppm	Sodium Na ppm	Sulfur SO_4-S ppm	Zinc Zn ppm	Manganese Mn ppm	Iron Fe ppm	Copper Cu ppm	Boron B ppm	Chloride Cl ppm
Results	15.7	5	149	136	356	205	3961	22	127	10.5	6	91	3.5	0.6	
		LOW		AVERAGE	HIGH										

This lab categorizes soil test values in five categories: **very low, low, medium, high and very high.**

But who decided what was “low” and “high”?

How much fertilizer or lime do I apply?

Soil Test Interpretation Guide

D.A. Horneck, D.M. Sullivan, J.S. Owen, and J.M. Hart

EC 1478 • Revised July 2011

- OSU EC 1478-E
- Most recent summary of applicable soil test methods used in the Pacific Northwest
- General reference: “approved” method, general interpretation: low, medium, high, excess
- More specific information provided in crop/region specific nutrient management guides

Secrets of soil test calibration

- Soil test value related to crop yield response for soils in a specific region
- Soil test values by themselves (no calibration to crop yield response) are interesting, but not very useful

Soil Testing Example (P)

- Standard" agricultural soil tests extract a portion of total soil phosphorus
- An effective soil test extractant mimics a plant root (extracts some of the "available" P)

Unavailable → Available → Soluble

Soil test value

- “Index” value
- Just like you can’t compare Dow vs. NASDAQ stock indexes, you can’t compare soil test P values obtained with different soil test extractants.
- To have value in diagnosing nutrient need, soil test value needs to be **calibrated** to crop response to nutrient addition

Soil test calibration experiments performed by OSU and land grant universities

- Conducted experiments at field sites with low to high soil test values
- Many farmers, many soils, one crop at a time
- Determined what soil test value is adequate or sufficient to support maximum crop production

Soil test calibration field experiments

- Each experiment at each field site had two fertilizer treatments (replicated within field):
  - No nutrient added
  - High rate of nutrient added

- Response to nutrient expressed as relative yield (%):

  (Crop yield without fertilizer)/(crop yield with fertilizer) x 100

- All other crop management factors optimized, uniform

Soil test interpretations are based on calibration curves developed from field experiments

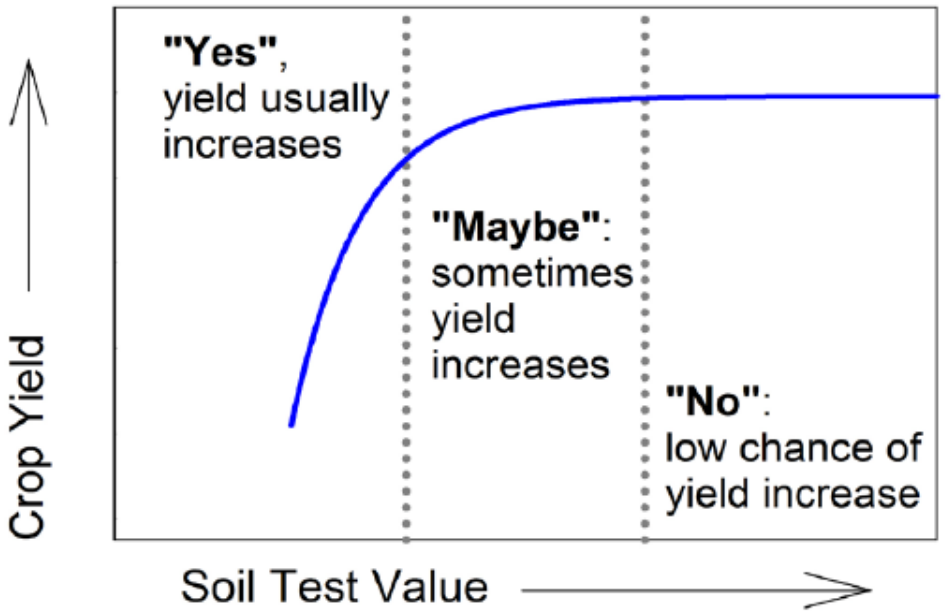


Figure 1. Soil test value vs. probability of crop yield response to nutrient addition. Crop yield increase due to nutrient addition is likely at low soil test values and unlikely at high soil test values. (Chart © Oregon State University. Prepared by Dan M. Sullivan.)

Source: OSU EC 1478-E (2011)

General soil test interpretation for P (all crops, EC1478-E)

Table 2. Phosphorus (P) soil test categories and suggested fertilizer rate recommendations.

	West of Cascades Bray P1 test P (ppm)	East of Cascades Olsen test P (ppm)	Recommendation (lb P_2O_5/acre)
Low	<20	<10	0–300
Medium	20–40	10–25	0–200
High	40–100	25–50	0–30
Excessive	>100	>50	0

Crop specific P recommendation

(found in fertilizer or nutrient management guide for specific crop in a region)

Table 2.—Phosphorus application rates for pastures.

If the Bray soil test for P is (ppm)	Apply this amount of phosphate (P_2O_5) (lb/a)
0–15	60–100
15–30	0–60
over 30	0

In: OSU Fertilizer Guide for Pastures (western OR). Revised 2000.

Soil analyses: west of Cascades

(pH < 7; precipitation 30 to 50+ inches)

- soil pH
- lime requirement: SMP buffer test
- Bray P1 phosphorus
- Exchangeable cations (Ca, Mg, K)
- hot-water extractable B
- Post-harvest NO3-N?
  - Sept 1-Oct 15

Interesting but probably not essential

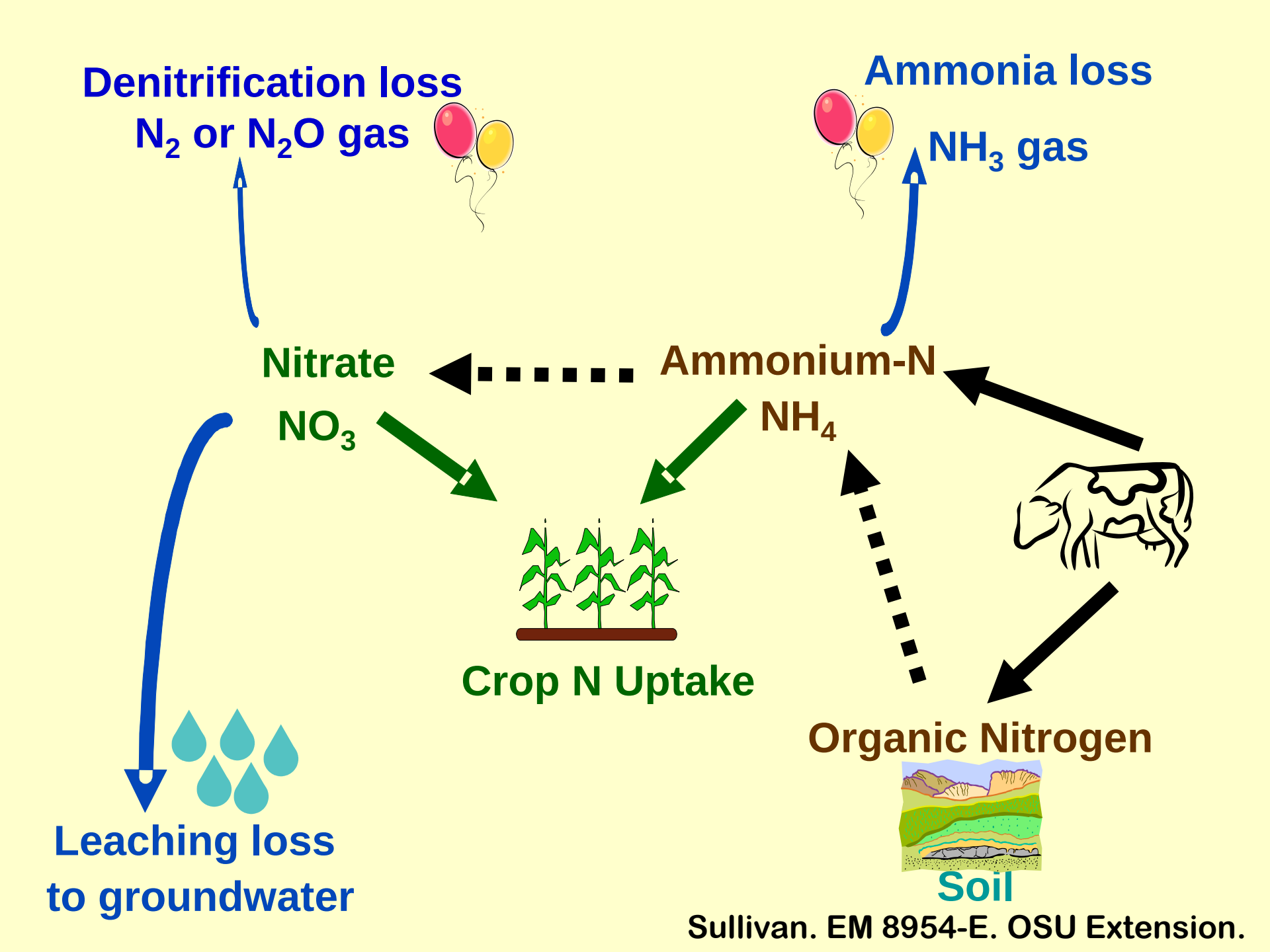
- Ammonium-N (NH4-N)
- Sulfate-S (SO4-S)
- Percent base saturation
- Cation exchange capacity (CEC)
- Nutrient ratios
- Soil texture
- Mineralizable N, total N
- Soil health score (Haney test)
- Organic matter or soil carbon
  - Sometimes useful for long term monitoring

General management for western Oregon acid soils

- Based on soil testing:
  - Apply lime to raise soil pH to 6.5 for all crops (except blueberries, red maple trees, and other acid loving plants)
  - Use fertilizer or compost to supply P, K, S, and micronutrients
- Apply N fertilizer based on crop demand (from university guides). **Soil tests not used to predict crop N need.**
- Reduce N fertilizer rate when following legume cover crop
- Reduce N fertilizer when organic fertilizer/compost applied often in previous 3 to 5 yr.

Nitrogen

- N fertilizer application is usually essential
- Soil testing is not used to predict crop N need
- Nitrogen recommendations in OSU guides are based on crop response to N fertilizer in field trials



Sullivan. EM 8954-E. OSU Extension.

Detailed nitrogen guidance in PNW 646

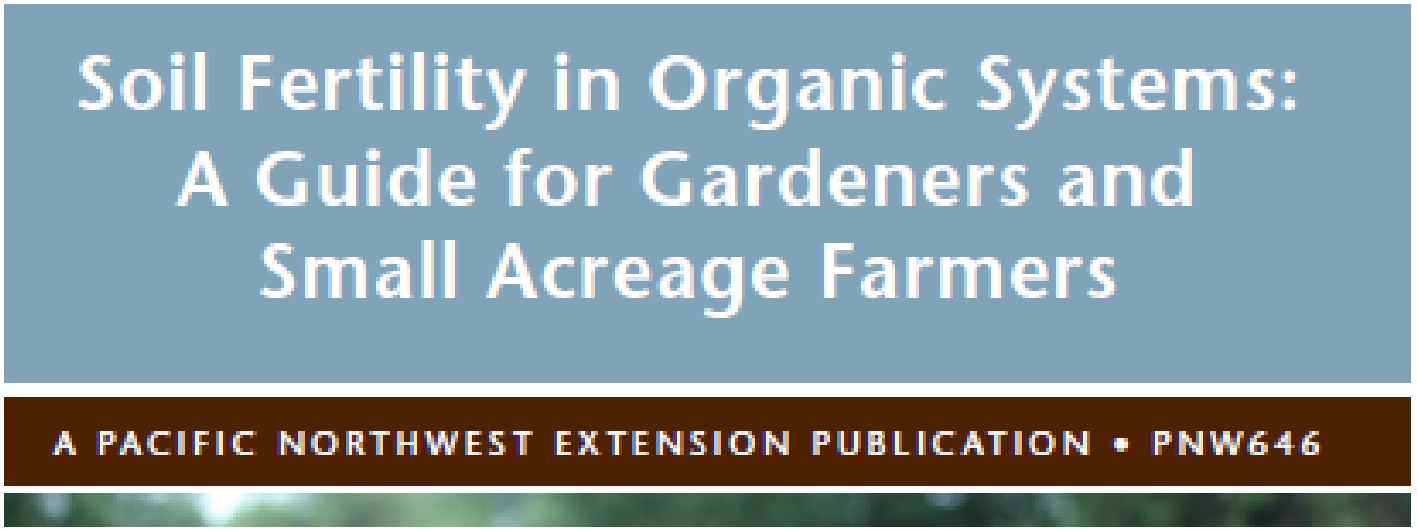


Table 1. Nitrogen requirement for vegetable crops (lb/1000 ft²)[a] based on seasonal nitrogen uptake (adapted from Gaskell et al. 2007).

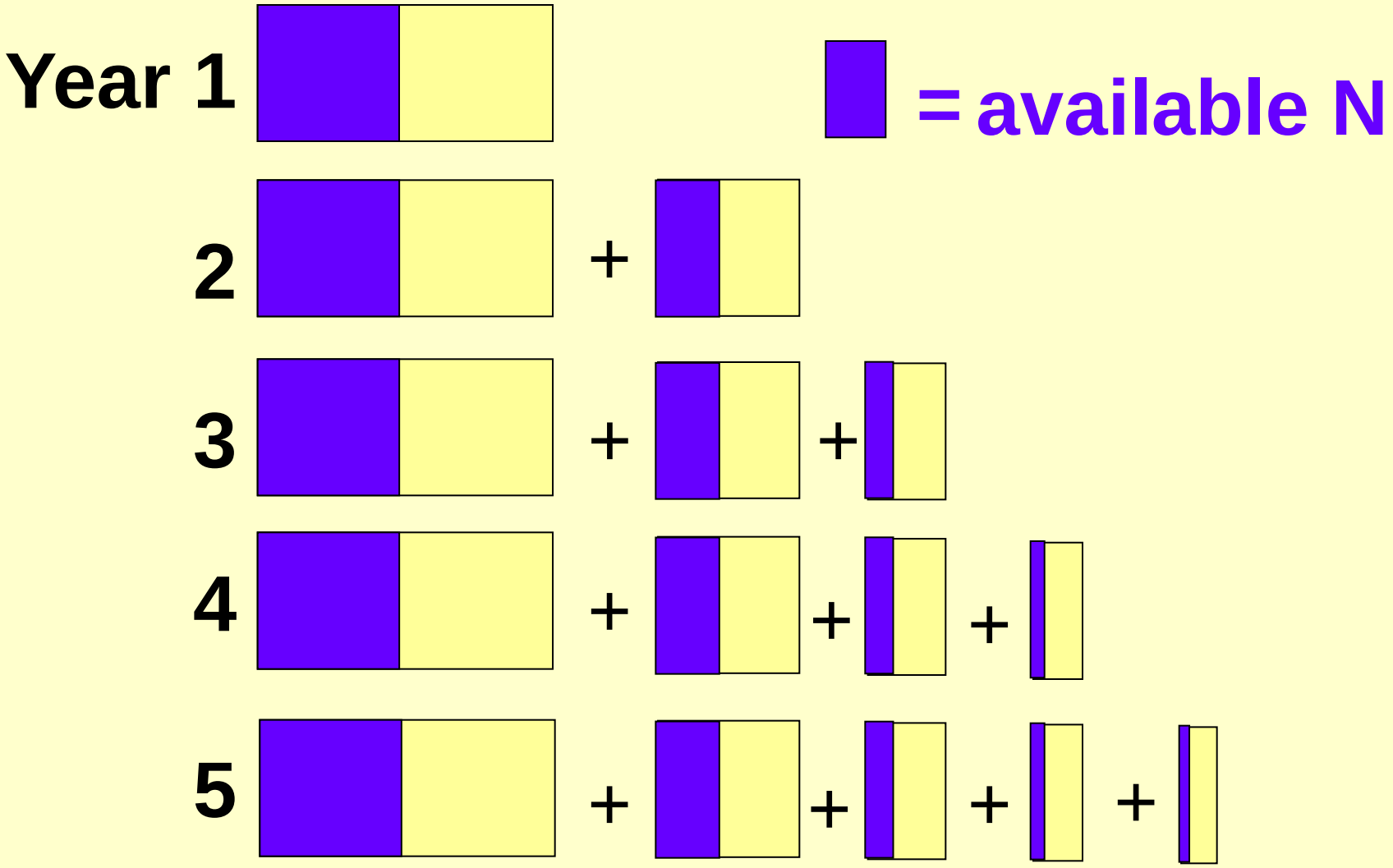
Low: 3 lb/1000 ft²	Med: 4 lb/1000 ft²	High: 5 lb/1000 ft²
Baby greens	Carrot	Broccoli
Bean	Corn, sweet	Cabbage
Cucumber	Garlic	Cauliflower
Radish	Lettuce	Celery
Spinach	Melon	Potato
Squash	Onion	
	Pepper	
	Tomato	

[a]Multiply values by 44 to aproximate the conversion of lb/1000 ft² to lb/acre.

Soil organic matter

- More N release from soils with frequent manure or compost application
- OSU nutrient management guides already allow for typical N release from soil organic matter
- So, soil organic matter number on your soil test report is interesting, but probably not useful to N management decision

Cumulative available N from an organic source



Crop specific guides will give guidance on timing of N fertilizer application (example: pastures)

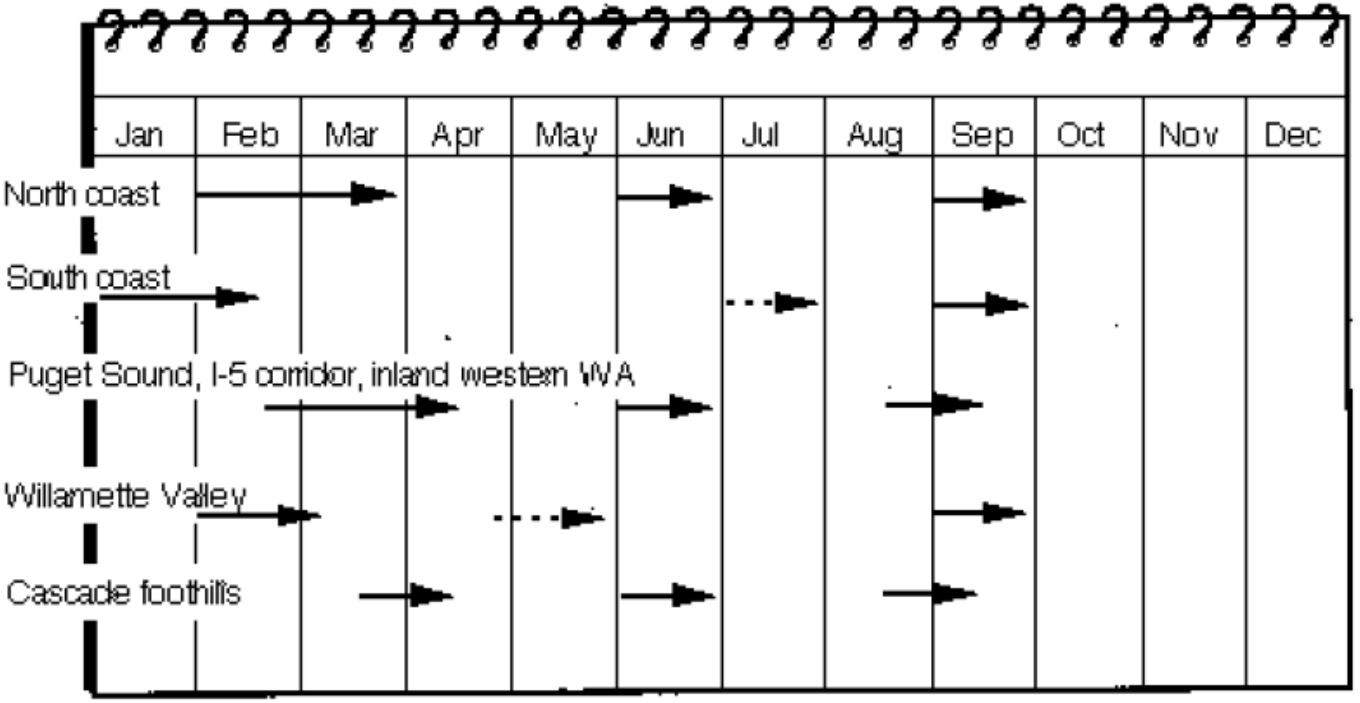


Figure 2.—Pasture nitrogen application calendar. Apply 50 to 60 lb N/a each time a solid arrow appears for your region. Additional applications for irrigated pastures are indicated by dotted lines. See nitrogen section in text for an explanation.

In: OSU FG-63. Fertilizer Guide for Pastures (western OR). Revised 2000.

Sulfur

- If soil S is low, other nutrients are not used efficiently
- But, like N, soil testing won't tell you how much S to add
- **Typical recommendation: 0.5 to 1 lb sulfate sulfur (S) per per thousand sq ft. each year**
- S fertilizers include ammonium sulfate, gypsum, or sulpomag (sometimes called KMag)
- If you apply compost or manure, S fertilizer usually not needed

Orchardgrass – S response

Three most important nutrient management decisions based on soil testing

- Apply lime as needed
- Apply lime as needed
- Apply lime as needed

What is pH?

pH units are logarithmic, like the Richter scale for earthquake severity

A pH of 5 is ten times more acidic than a pH of 6

What is the effect of soil pH on plants?

When soil is too acidic (low pH):

- Plant root growth and crop yield is reduced
- Legumes are especially sensitive to acid soil

Crops differ in their tolerance to acid soil (low pH)

Lime is the “antacid” for soil acidity

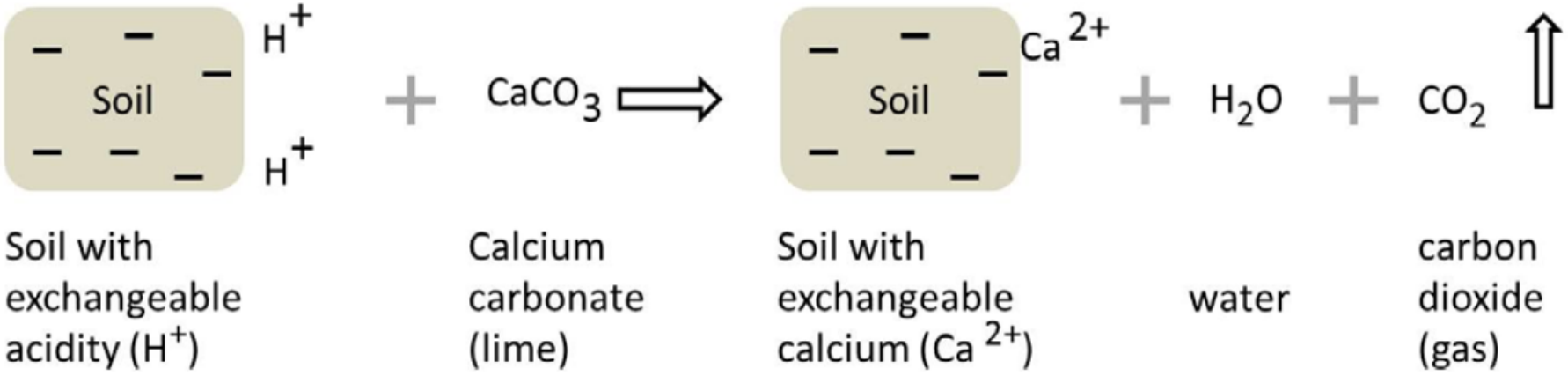
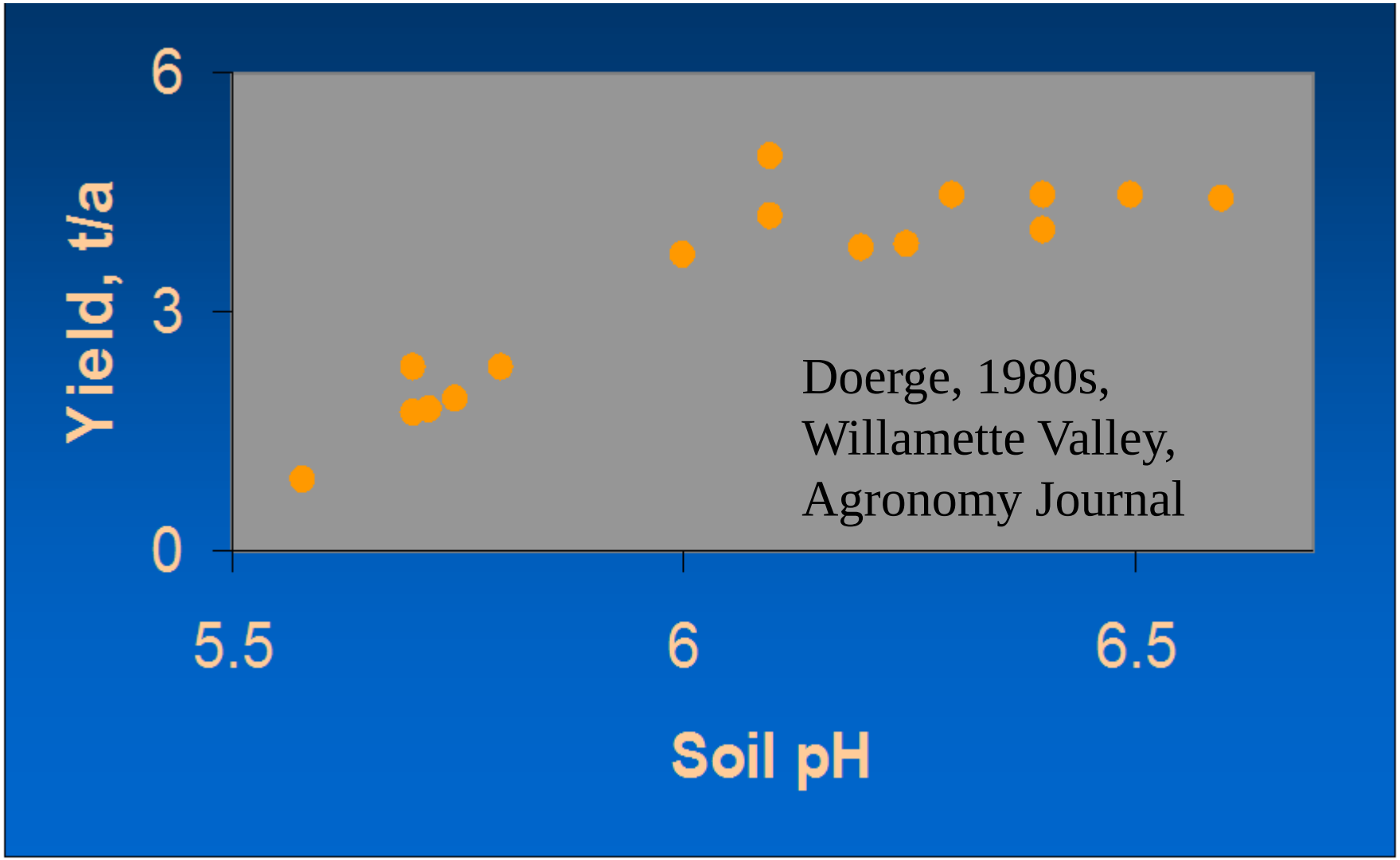


Figure 3.—Soil acidity reacts with lime to form water and carbon dioxide. The carbon dioxide gas is lost to the atmosphere. This chemical reaction continues until all of the lime has reacted. Figure by Dan Sullivan.

Lime to avoid a crop yield "crash landing" Example: alfalfa



Applying Lime to Raise Soil pH for Crop Production (Western Oregon)

OSU EM 9057 (2013)

EM 9057 • May 2013

N.P. Anderson, J.M. Hart, D.M. Sullivan, N.W. Christensen, D.A. Horneck, and G.J. Pirelli

OSU Marion County Extension office archives

Figure 1.—Lime application in Marion County, OR, about 1960.

Gale Gingrich

Figure 2.—Lime application in Marion County, OR, 2012. Although application equipment has changed over the decades, techniques have not, and liming remains an important tool for maintaining crop yield.

See also OSU Guide EM 9061 (2013)
Soil Acidity in Oregon:
Understanding and Using Concepts for Crop Production

Table 1.—Minimum soil pH values recommended for crops grown in western Oregon.[a]

Crop	Minimum pH
Alfalfa	6.5
Beans and cucurbits	5.8
Blueberries, rhododendrons, and azaleas	4.5
Cereals or small grains[b]	5.5–5.8
Christmas trees	5.0
Corn	
Grain or silage	5.5
Sweet corn	5.8
Forage and seed legumes	
Crimson/subterranean clovers, vetch[b]	5.5–6.0
Red clover for forage or seed	6.0
White clover for forage or seed	5.8
Garlic	6.5
Hops	5.7
Pasture, seed, and turf grass[b]	5.5–5.8
Peppermint	5.6–6.0
Shade, ornamental, fruit, and nut trees[b, c]	5.5–5.8
Vegetables, brassica (broccoli, etc.)	6.3
Vegetables, assorted for small acreage	6.5[d]

Target for soil pH:
above minimum value

Source: OSU EM 9057

When is liming needed?

- Liming “fixes” (increases) soil pH slowly
- It takes 6 to 12 months for full reaction with soil
- Lime has to be tilled into soil to get best results
- So plan ahead
- If you are planting a perennial agronomic crop, apply enough lime for the life of the crop

How much lime to apply?

- Goal is to keep soil pH from getting too low.
- Use soil testing to determine lime need.
- Get on a schedule, like going to the dentist…
- Consider applying modest rate of lime every 4 years, rather than a high rate of lime every 10 years.

2 to 5 ton of 100-score lime per acre is required to change soil pH by 1 unit (for example, from pH 5 to pH 6)

Table 2.—Soil resistance to pH change (soil pH buffering capacity).

Soil series	Lime application needed for 1-unit pH increase (t/a)
Newberg	2.2
Woodburn, Chehalis, Willakenzie	2.6–2.8
Malabon, Dayton, Powell	3.2–3.3
Steiwar, Laurelwood, Cascade	3.6–3.7
Sauvie, Amity	4.0–4.1
Bashaw, McBee, Nekia, Jory	4.4–4.6
Salem	5.3

Note: Table 2 is not intended to replace the SMP buffer test and should not be used to make lime rate recommendations. It is intended only to illustrate lime rate differences related to different organic matter and clay content (CEC) of various soil types. Table by John Hart. Data from Peterson, 1971.

One ton of lime per acre =

About

5 lb lime per 100 square ft

Or

50 lb lime per thousand square ft.

Source: OSU EM 9057

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