



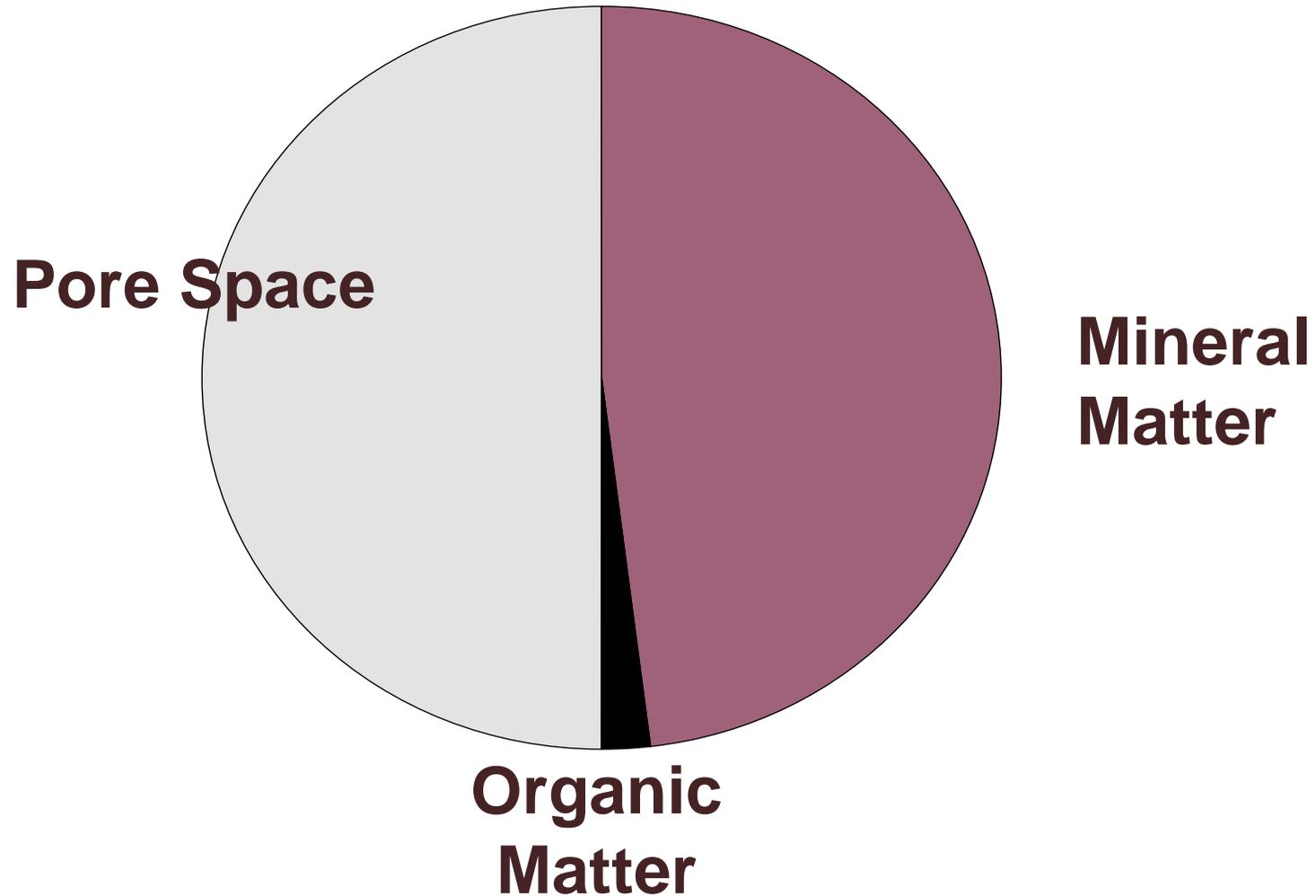
# Soils and Biosolids Nutrient Management

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 EXTENSION

# Soil Components



# The Soil Ecosystem



**Residue decomposition**  
**Nutrient cycling**  
**Aggregation and porosity**  
**Enhance plant growth**  
**Break down contaminants**

*The soil is the great connector of our lives, the source and destination of all. - Wendell Berry*

# Soil Organisms



Bacteria, fungi, actinomycetes, protozoa, nematodes,  
arthropods, earthworms

*Pictures courtesy D. Collins, M. Fauci and D. Bezdicek*

# Soil Air and Water



- **Water Movement**  
How quickly water moves through soil
- **Water Holding Capacity**  
How much water a soil can hold available for plant growth

# Pore Space and Air-Water Relations

- Soil acts like a sponge
- Macropores control infiltration and drainage
- Capillary pores control water holding capacity
- Micropores hold unavailable water

# What Affects the Size of the Soil Pores?

- Soil texture
- Soil structure
- Compaction and disturbance
- Organic matter

*To be a successful farmer one must first know the nature of the soil.*

*- Xenophon, 400 B.C.*

- **Texture**
- **Structure**
- **Compaction**
- **Organic Matter**



# Texture: Soil Particle Sizes

Sand .05-2 mm

Silt .002-.05 mm

Clay <.002 mm

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Coarse Fragments >2 mm

# Texture: Approximate Surface Areas of 1 gram Samples



Coarse sand:  
one dollar

Fine clay:  
soccer field



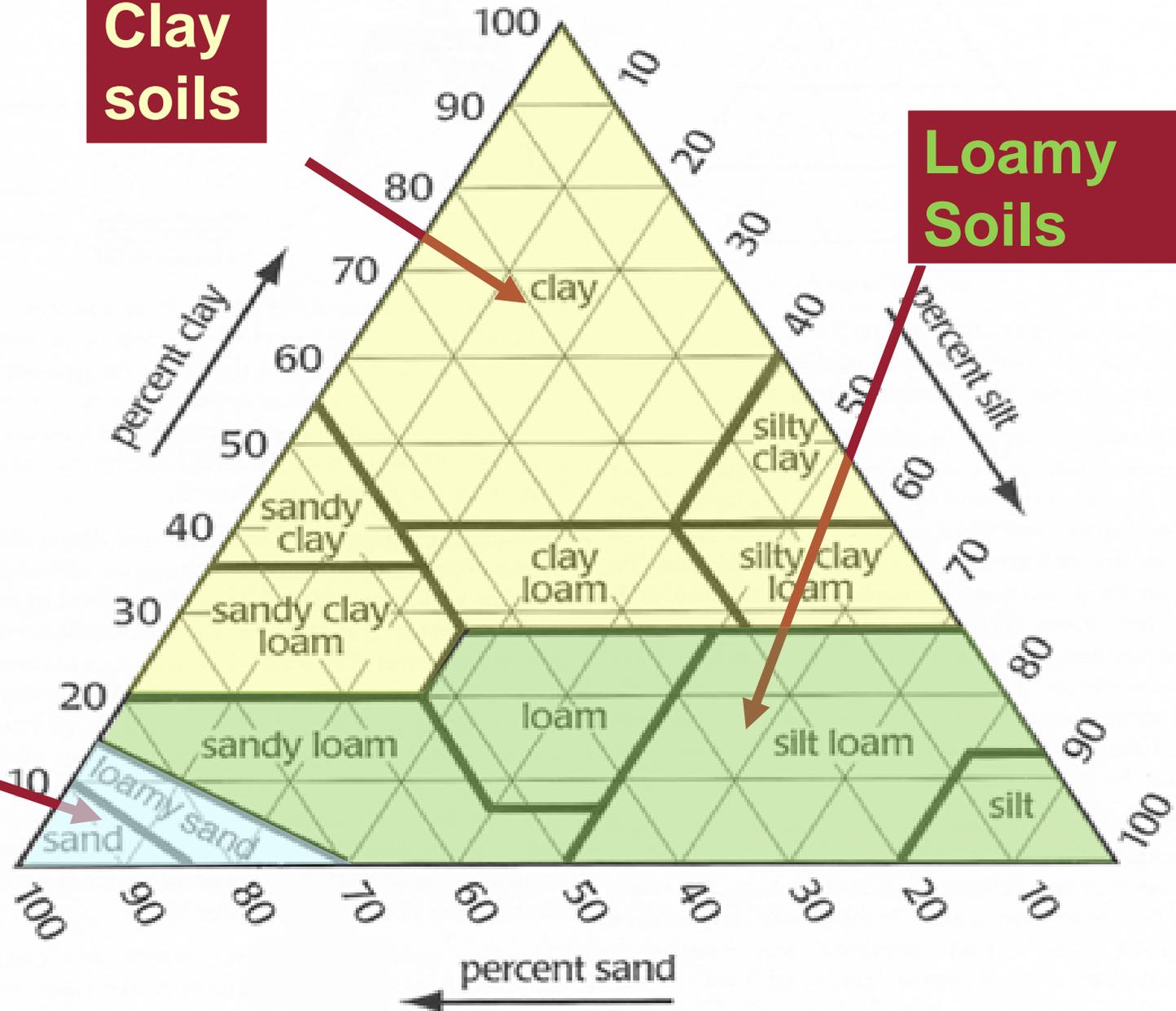
# Textural Triangle



**Sandy soils**

**Clay soils**

**Loamy Soils**



- Texture
- Structure
- Compaction
- Organic Matter



# Soil Structure

Aggregation of Sand, Silt, and Clay Particles



## Structure affects:

- Macroporosity
- Infiltration
- Aeration

# Formation of Soil Structure

- Growth of roots and movement of organisms create pores and aggregates
- Soil bacteria make glues that stabilize aggregates
- Fungi help bind aggregates
- Physical, chemical processes also involved



- Texture
- Structure
- Compaction**
- Organic Matter



## Natural Compaction:

- Basal glacial till
- Very compact
- Nearly impermeable



## Human Compaction:

- Clearing
- Construction
- Traffic



- Texture
- Structure
- Compaction
- Organic Matter

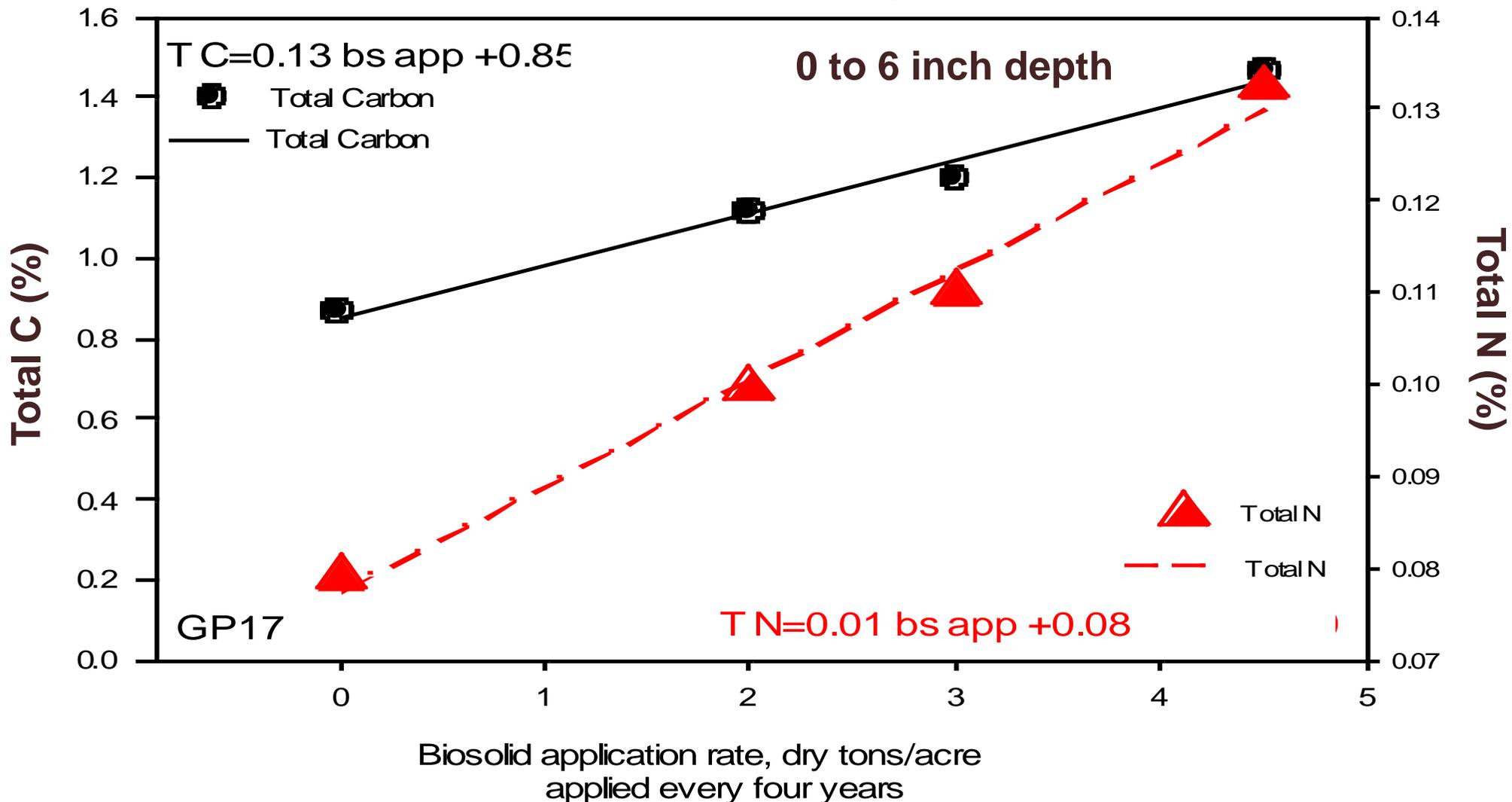


# Why is Organic Matter Important?

- Structure and macropores
- Water holding capacity
- Infiltration
- Nutrient supply
- Biological activity
- Improved root environment

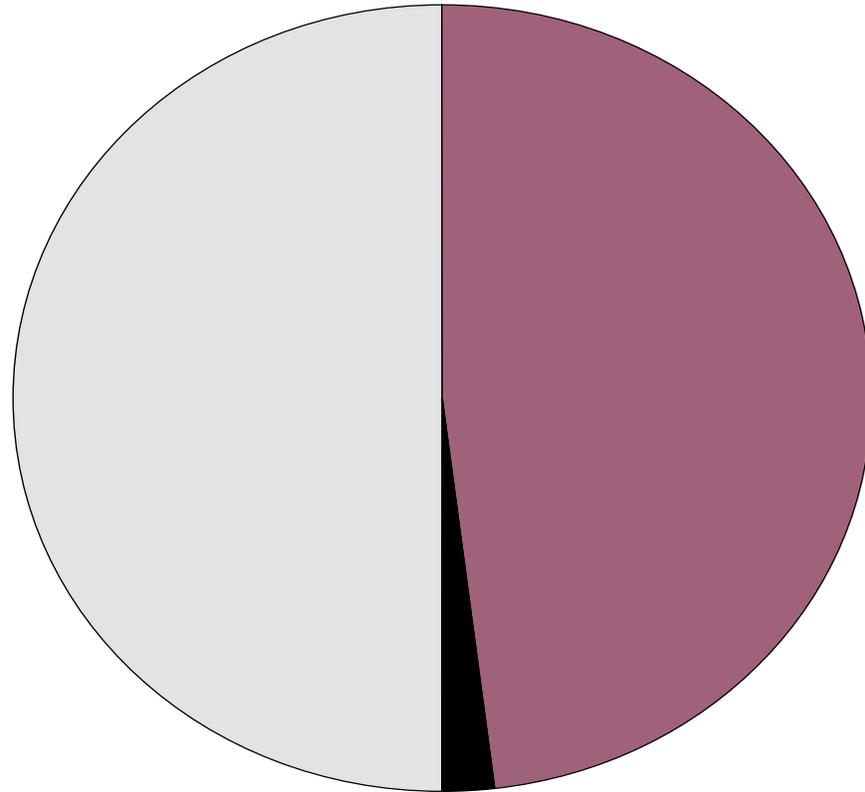


# Biosolids and Soil Organic Matter



Soil C and N after 4 biosolids applications to dryland wheat

# Organic Matter: One-Minute Drill



**What soil components does this pie chart show?**

# Nutrient Management

- Meet crop nutrient needs
- Maintain soil quality
- Conserve resources
- Protect water quality - reduce leaching and runoff risk

# Plant Nutrients

## Major Nutrients

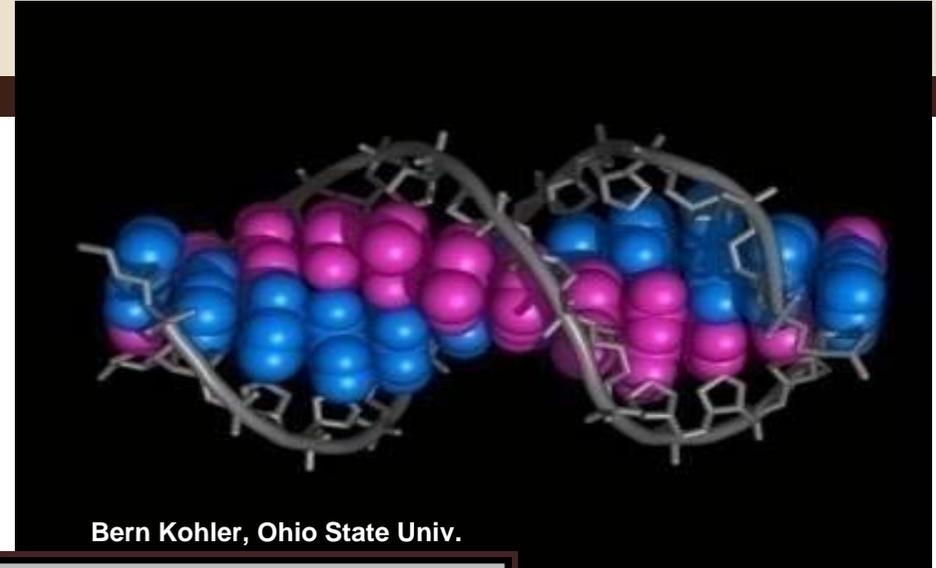
- Nitrogen
- Phosphorus
- Potassium
- Calcium
- Magnesium
- Sulfur

## Micronutrients

- Boron
- Iron
- Manganese
- Zinc
- Copper
- Chloride
- Molybdenum

# What Do Nutrients Do?

## *Example: Nitrogen*

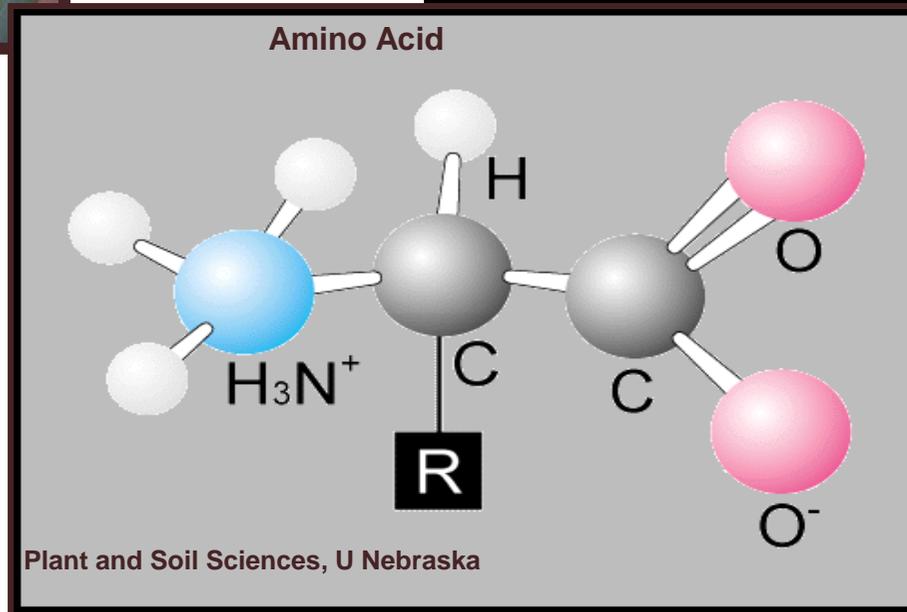


Bern Kohler, Ohio State Univ.

**DNA**

**Chlorophyll –  
photosynthesis**

**Amino acids  
and proteins**

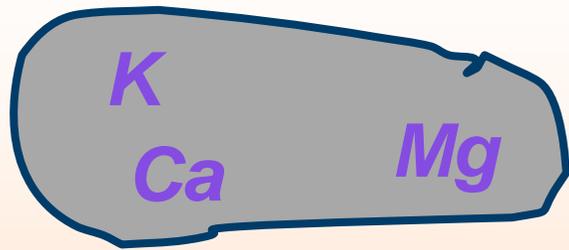


# How Do Nutrients Become Available to Plants?



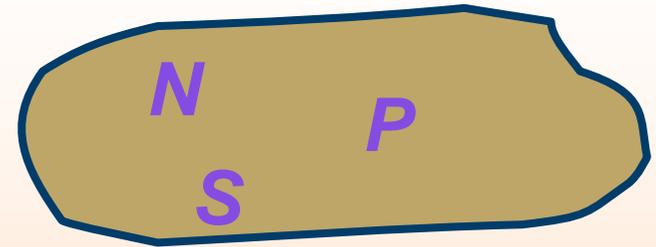
# What Happens to These Nutrients When It Rains?

Mineral Matter



Not available

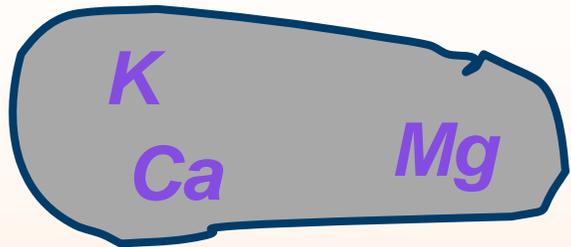
Organic Matter



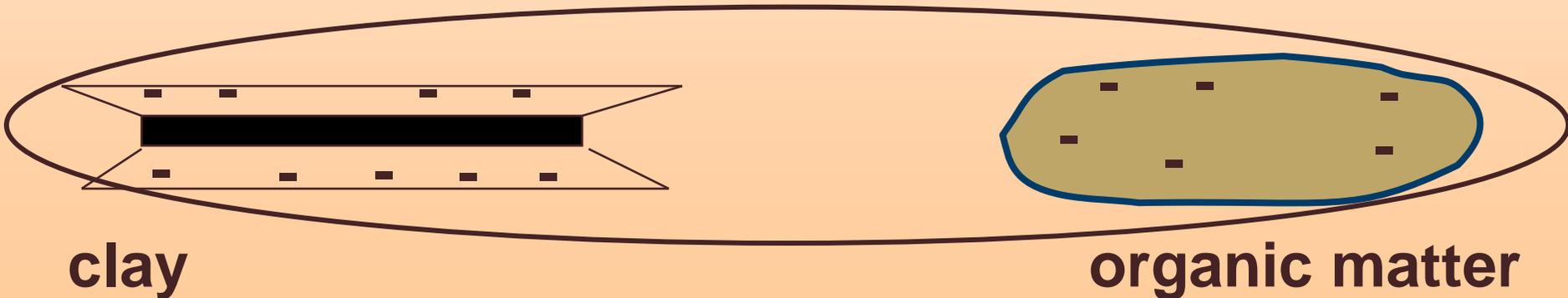
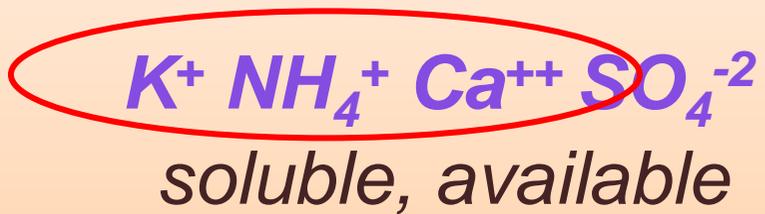
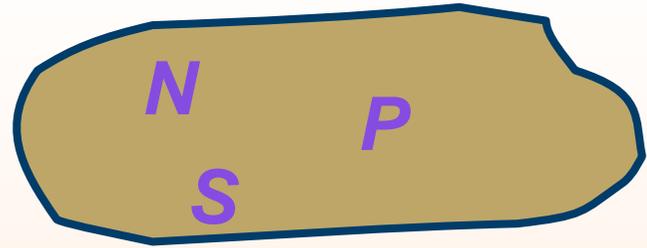
Weathering

Biological release

$K^+$   $Ca^{+2}$   $NH_4^+$   $SO_4^{-2}$   
*soluble, available*

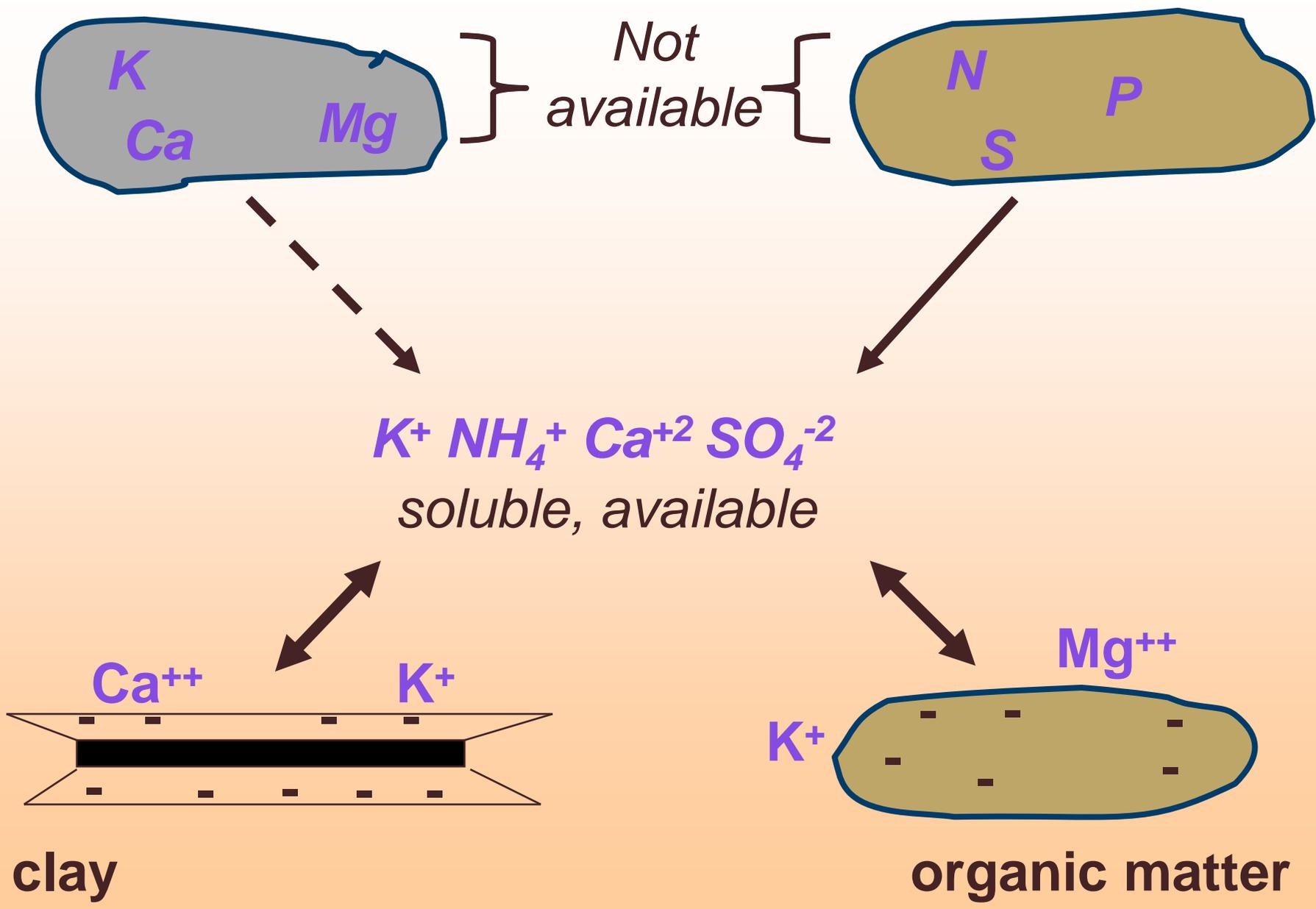


Not available



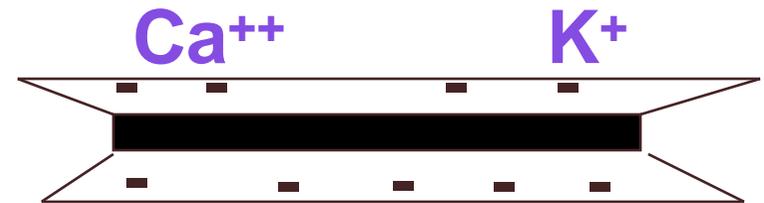
clay

organic matter



# Cation Exchange Capacity

- Cation (+ ion)
- Anion (- ion)
- Cation exchange capacity (CEC):  
Negative sites on clay and organic matter that can hold cations.



# Nutrient Anion Availability

**Anion**



**Binding**

strong

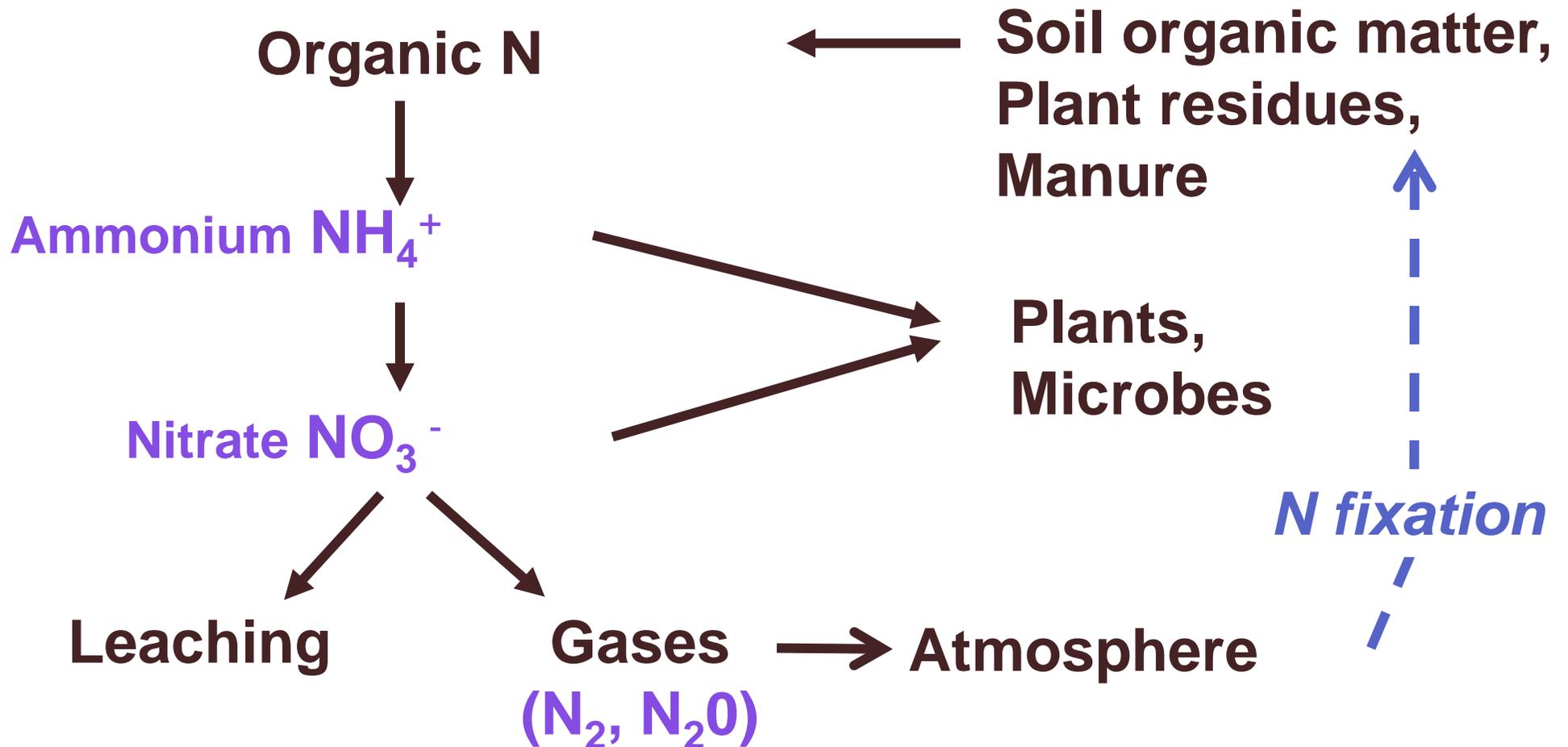
weak

**Solubility**

low

high

# Nitrogen Cycle



# Biosolids and Other Nutrients

- These nutrients accumulate in the soil when biosolids are applied to meet N needs:  
*Phosphorus*  
*Zinc*
- This nutrient will decline in soil if biosolids are the sole source of nutrients:  
*Potassium*

# Nutrient Uptake

The forms of nutrients taken up by plants are the same –

Whether the source of the nutrients is the soil, an organic fertilizer, or a manufactured fertilizer.

But, our management  
must maintain soil  
organic matter over the  
long run.



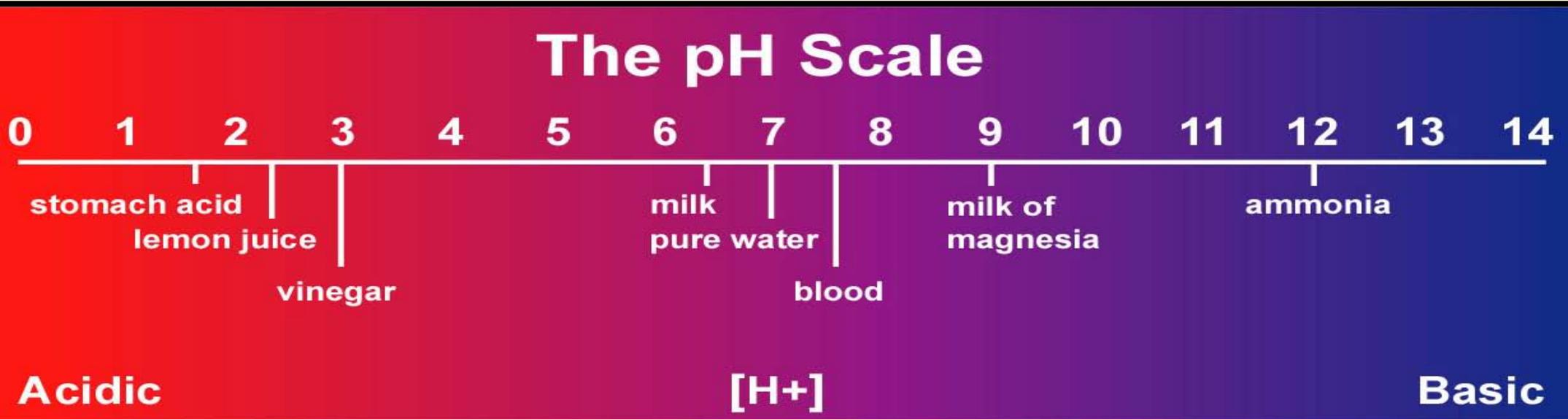
*The nation that destroys its soil,  
destroys itself.*

*-Franklin Delano Roosevelt*



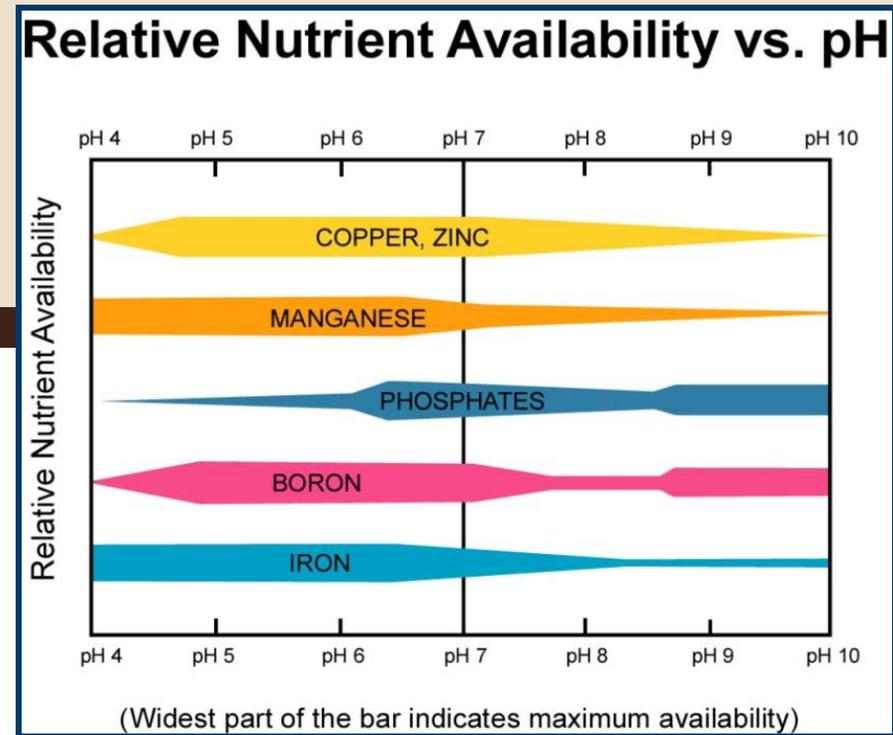
# Soil pH

- Indicates relative acidity or alkalinity
- pH 7 = neutral; less than 7 = acid; more than 7 = alkaline or basic
- Logarithmic scale



# Why is pH Important?

- Nutrient availability
- Availability of toxic metals
- Microbiological activity



# What Affects pH?

- **Climate**

Humid areas tend to have acid soils, and arid areas tend to have alkaline soils.

- **Parent material**

Some parent materials contain lime and keep soil pH higher.

- **Management**

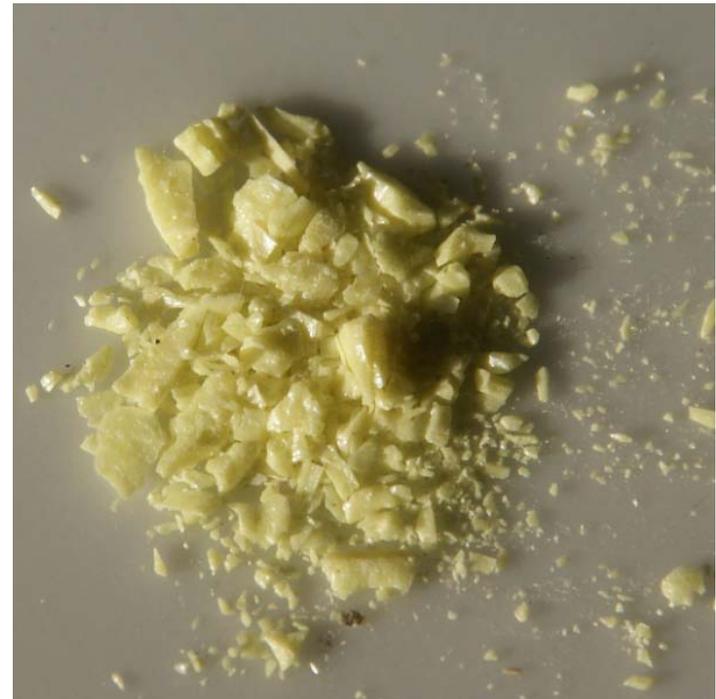
Many fertilizers tend to produce acidity.

# Desirable pH Ranges

- Vegetables 6 to 7.5
- Pastures 5.5 to 8
- Acid loving plants 4.5 to 5.5

# Modifying Soil pH

- Lime ( $\text{CaCO}_3$ ) neutralizes acidity and increases pH
- Elemental sulfur generates acidity and decreases pH



<http://images-of-elements.com/sulfur-4.jpg>

# Biosolids and Soil pH

- Mineralization of organic N and S causes decline in pH (more acid)
- Alkaline-stabilized biosolids increase soil pH (liming effect)



# Soil Testing

# Soil Testing

- **Theory:** Extracts “plant-available” nutrients.
- **Results:** Used to predict nutrient availability and need.
- **Biosolids management:** Indicates which biosolids nutrients are needed. Identifies excessive nutrient levels in soil.

# Soil Testing Requirements

- Vary, depending upon your permit
- Most soil testing is voluntary; much of it is useful for biosolids management.

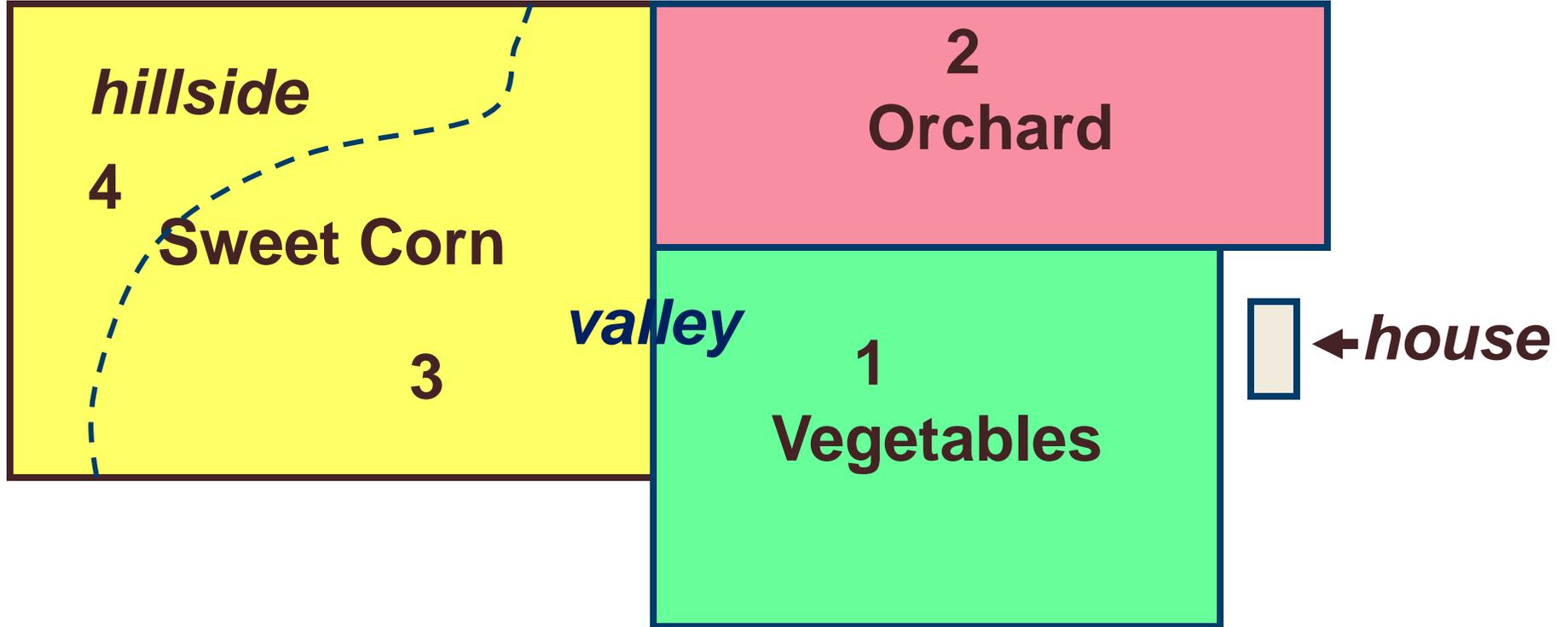
# What Is a Soil Test?

- A chemical evaluation of the nutrient supplying capability of the soil.
- Soil test results are calibrated with crop response research to develop fertilizer recommendations.

# Types of Tests

- **Pre-application tests:** nutrients, metals, (nitrate east of Cascades)
- **Post-harvest nitrate:** a check on application rates.
- **Nutrients:** Check on nutrient sufficiency, biosolids benefits.

# Make a Sampling Plan



# When to Take a Sample?



- Sample before applying biosolids or fertilizer
- Repeat every 2-3 years

# How to Take a Representative Sample?



Take **15-20** small samples!



**0-12 inches deep**



**Mix them in a plastic bucket**

# Mix the Sample and Spread It to Dry



*Dry it in  
fresh air*



# When the Sample is Dry:



***Mix it again***



***Put it in a plastic bag  
and close the bag***



***Send it to an  
agricultural  
laboratory***

# Sampling Tools

Use tools that collect uniform cores

**Hydraulic Probe**



**Hand Probe**



# How Deep to Sample?

- Nutrients, typically 12 inches.
- Nitrate 12 inches, except for dryland grain production, where entire root zone is sampled.

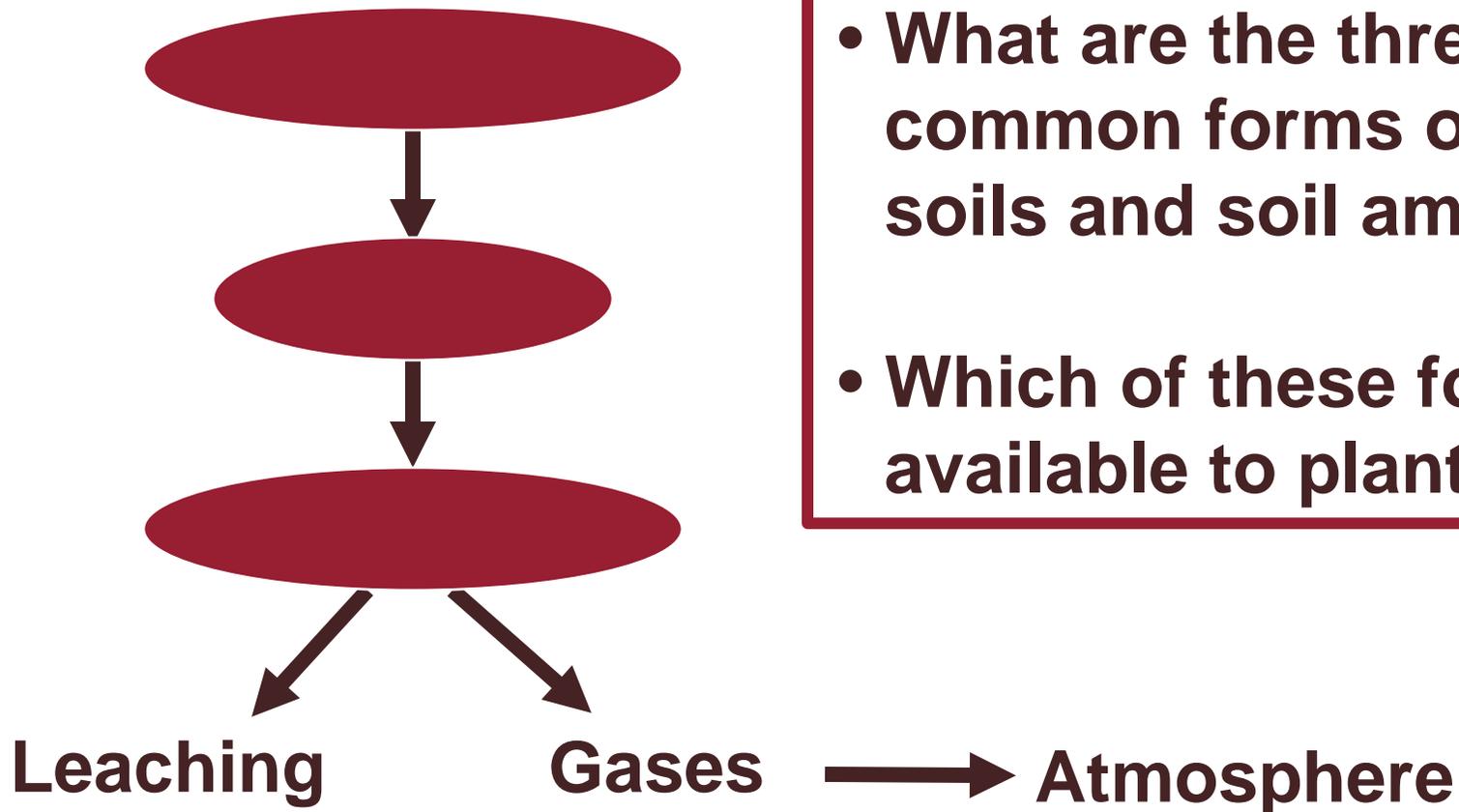
# Choosing a Lab

- Does the lab routinely do agricultural tests?
- Do they use OSU or WSU test methods?
- Do they give fertilizer recommendations?
- What information do they need?
- How to send sample?
- Cost?
- Turn-around time?
- What does report look like?

# Choosing a Lab

- **Quality assurance:** Does lab participate in proficiency testing program or sample exchange?
- **Quality assurance:** Submit a “known” sample for a check.

# One-Minute Drill



- What are the three most common forms of nitrogen in soils and soil amendments?
- Which of these forms are available to plants?

# Soil Nitrate Tests

- **Pre-sidedress nitrate test**
  - Mid-season nitrate test to determine need for additional N.
  - Calibrated for corn.
  - Research on other crops in progress
- **Post-harvest nitrate test**
  - Is excess leachable N in soil at end of season?
  - Use to modify next year's N management.

# Soil Nitrate Tests

- **PSNT:**
  - taken when corn is 6-12 inches tall, or similar growth stage for other crops
  - Sample 0-12 inch depth.
- **Post harvest test:**
  - September 1 to October 15
  - Sample 0-12 inch depth.
  - Sample preservation is important
- **Reference** - EM8650. The Pre-Sidedress Nitrate Test

# Interpreting Soil Tests

- Nutrient status  
Low, medium, high
- Fertilizer recommendation
- Reference:  
EC 1478. Soil Test Interpretation Guide

# Phosphorus Soil Test Interpretation

- Bray test (acid soils):

|           |               |
|-----------|---------------|
| Low       | < 20 ppm      |
| Medium    | 20 to 40 ppm  |
| High      | 40 to 100 ppm |
| Excessive | > 100 ppm     |
- Olsen test (alkaline soils)
- Acetate or Morgan test (acid soils)

# Potassium Soil Test Interpretation

Low < 150 ppm

Medium 150 to 250 ppm

High 250 to 800 ppm

Excessive > 800 ppm

# Calcium Soil Test Interpretation

Low < 5 meq/100g soil

Medium 5 to 10 meq/100g

High >10 meq/100g

*(sometimes units are cmol/kg)*

# Magnesium Soil Test Interpretation

Low:  $< 0.5$  meq/100g soil

Medium: 0.5 to 1.5 meq/100g

High:  $> 1.5$  meq/100g

*(sometimes units are cmol/kg)*

# Boron Soil Test Interpretation

Low < 0.5 ppm

Medium 0.5 to 2 ppm

High > 2 ppm

# Soil Sampling and Interpretation Information

<http://www.soils1.org>

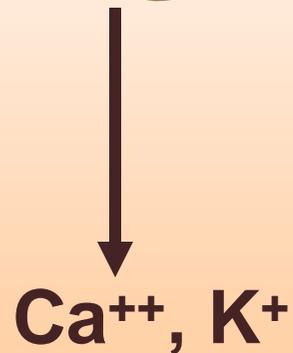
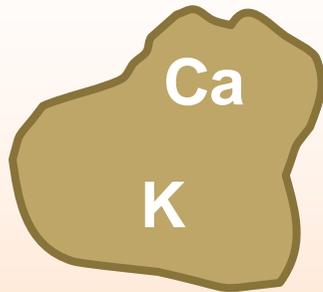
Click on “*Soils and Soil Testing*”  
for information on soil sampling,  
soil testing labs, and soil test  
interpretation.



# Biosolids Nutrients and Agronomic Rate Calculation

# Soil is full of nutrients, but most are not available to plants

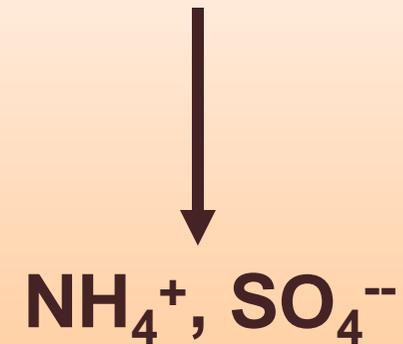
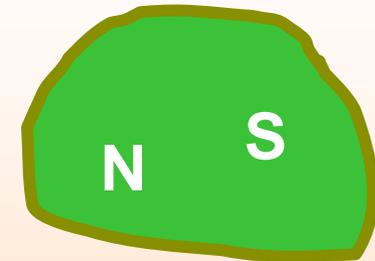
**Mineral**



*Insoluble, unavailable*

*Soluble, available*

**Organic**



# One-Minute Drill

- Describe the difference between total nutrient content and plant-available nutrient content of biosolids.
- What do you need to know to estimate the fertilizer N replacement value of biosolids?

# Agronomic Rate Goals

- **Environmental:**  
Balance crop N demand with plant-available N to prevent nitrate leaching.
- **Economic:**  
Provide enough N for near maximum yield and quality of crop.

# Agronomic Rate Calculation



# Agronomic Rate Calculation

- Soil and crop information
- Other sources of plant-available N
- Estimate plant available N needed from biosolids
- Biosolids data
- Estimate plant available N per dry ton of biosolids
- Calculate agronomic rate
- Convert to “as-is” basis

# Example 1: Grass Hay, West of Cascades

- Soil: *Jory silty clay loam*
- Crop: *grass hay*
- Yield goal: *2-3 dt/a*
- Plant-available N needed: *120 lbs N/acre*
- Plant available N from other sources:  
*none*

# Example 1: Grass Hay, West of Cascades

- Biosolids form: *solid*
- Biosolids processing: *anaerobic*
- Method of application: *surface*
- Days before incorporation: *never*
- Expected application season: *April-May*
- Biosolids analysis: *Mom's analytical services*

# Example 2: Dryland Wheat, Columbia Plateau

- Soil: *Walla Walla silt loam*
- Crop: *Wheat-fallow*
- Yield goal: *65 bushels/acre (sw wheat)*
- Plant-available N needed: *110 lbs/acre*
- Plant available N from other sources:  
*Preplant N in root zone - 85 lb/acre*

# Example 2: Dryland Wheat, Columbia Plateau

- Biosolids form: *solid*
- Biosolids processing: *anaerobic*
- Method of application: *incorporated*
- Days before incorporation: *4*
- Expected application season: *Sept.-Oct.*
- Biosolids analysis: *Bob's Fly by night services*

# On The Web

## **Biosolids publications and links:**

<http://www.soils1.org> "*Biosolids*" page

## **Direct link to spreadsheet:**

<http://cru.cahe.wsu.edu/CEPublications/pnw0511e/pnw0511e.pdf>

## **Soil Testing:**

<http://www.soils1.org> "*Soils and Soil Testing*" page