# Liming strategies: Buffer pH vs. soil type

Picture: www.braenstone.com/agricultural-lime/

SDSU Extension

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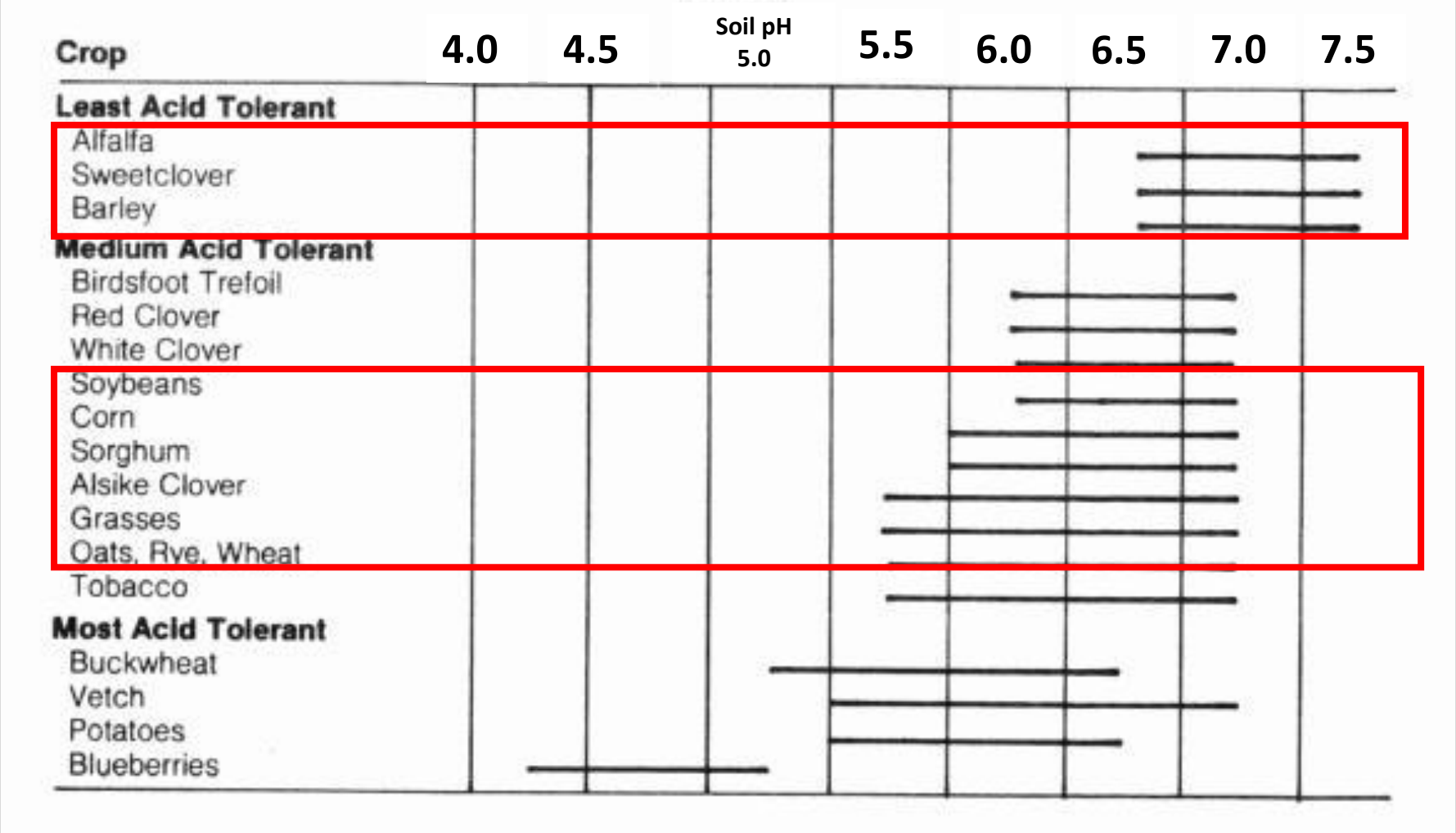
# Background

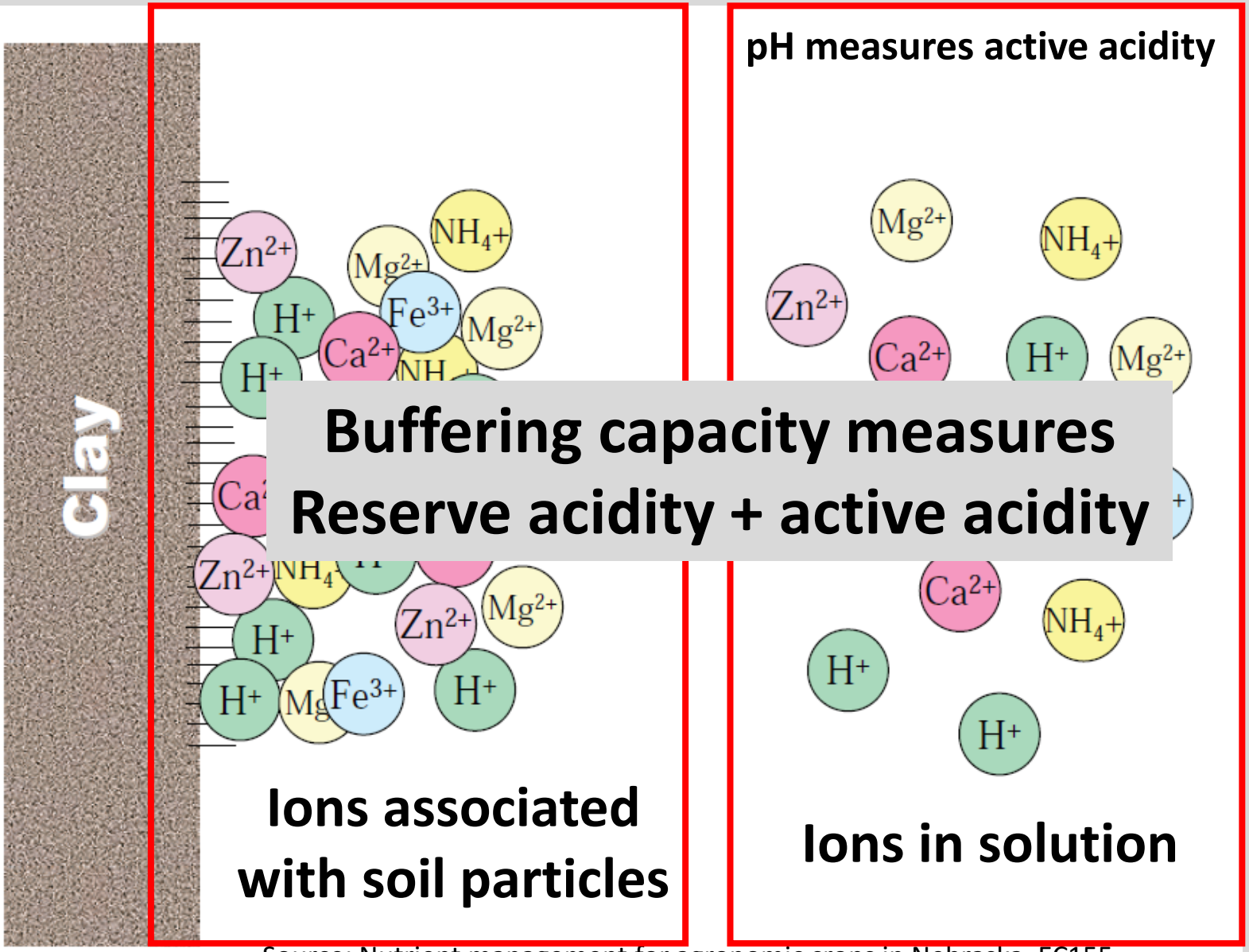
# Step 1: Test soil pH

## SD lime response: pH < 5.8 (6 in.)




Source: Spies and Harms. Soil acidity and liming of Indiana soils. In Agronomy Guide AY-267

# Step 2: Determine buffering capacity



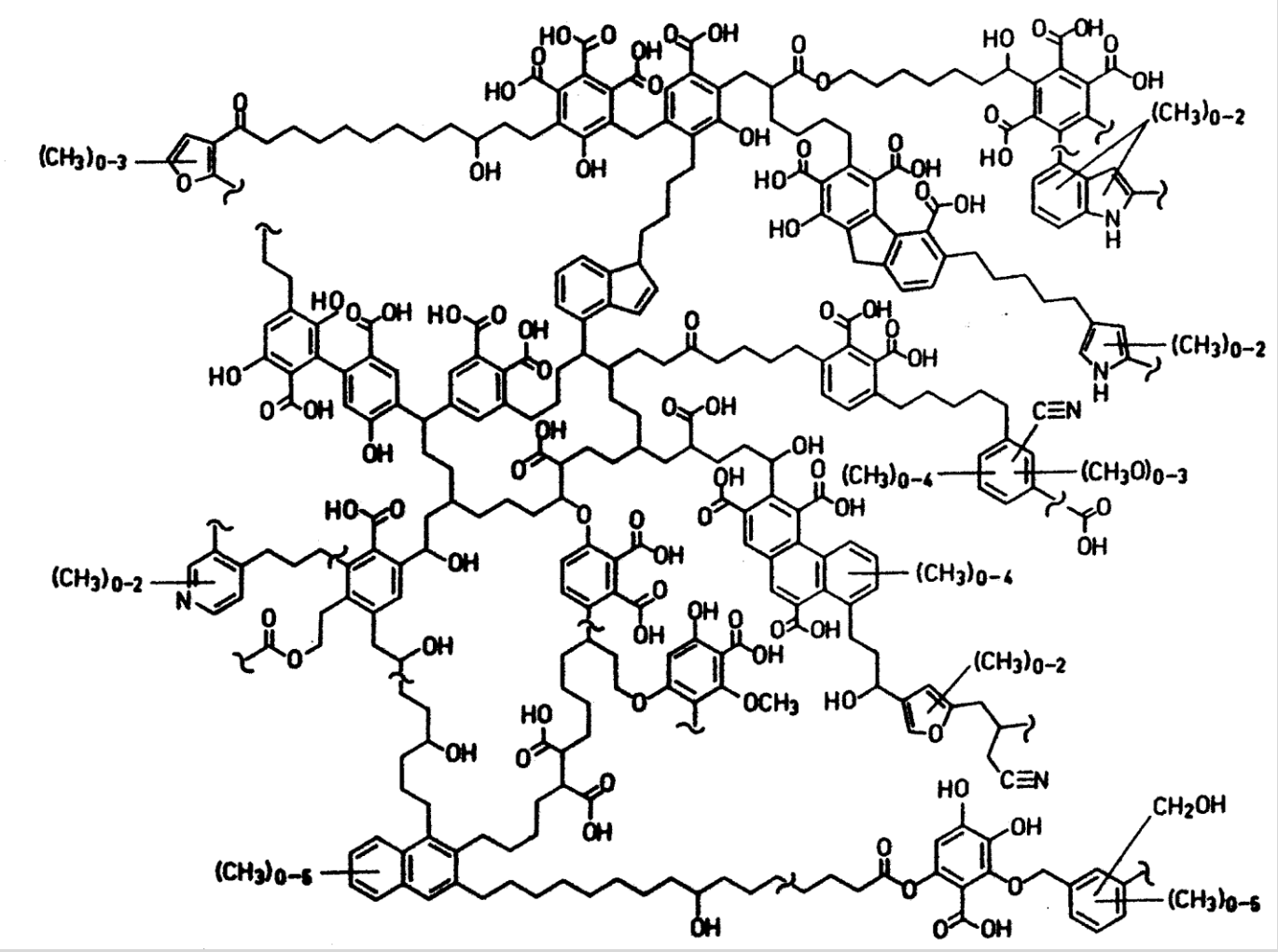

Source: Nutrient management for agronomic crops in Nebraska, EC155

# What are the soil factors that likely need to be considered when estimating buffering capacity?

Source: https://iowaagliteracy.wordpress.com/2017/12/21/why-do-they-do-that-liming-fields/

# Sources of reserve acidity

- Organic matter

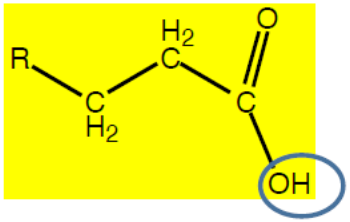


# Sources of reserve acidity

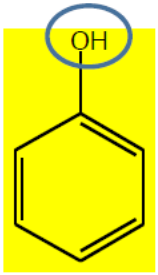
*OM functional groups*

Acidic functional groups (donate protons, become negatively charged)

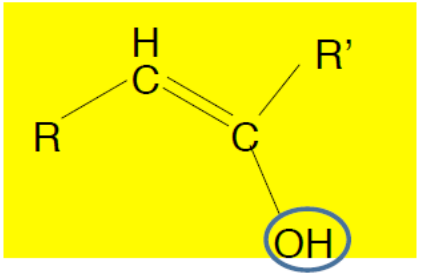
**Carboxyl**




**Phenolic-OH**

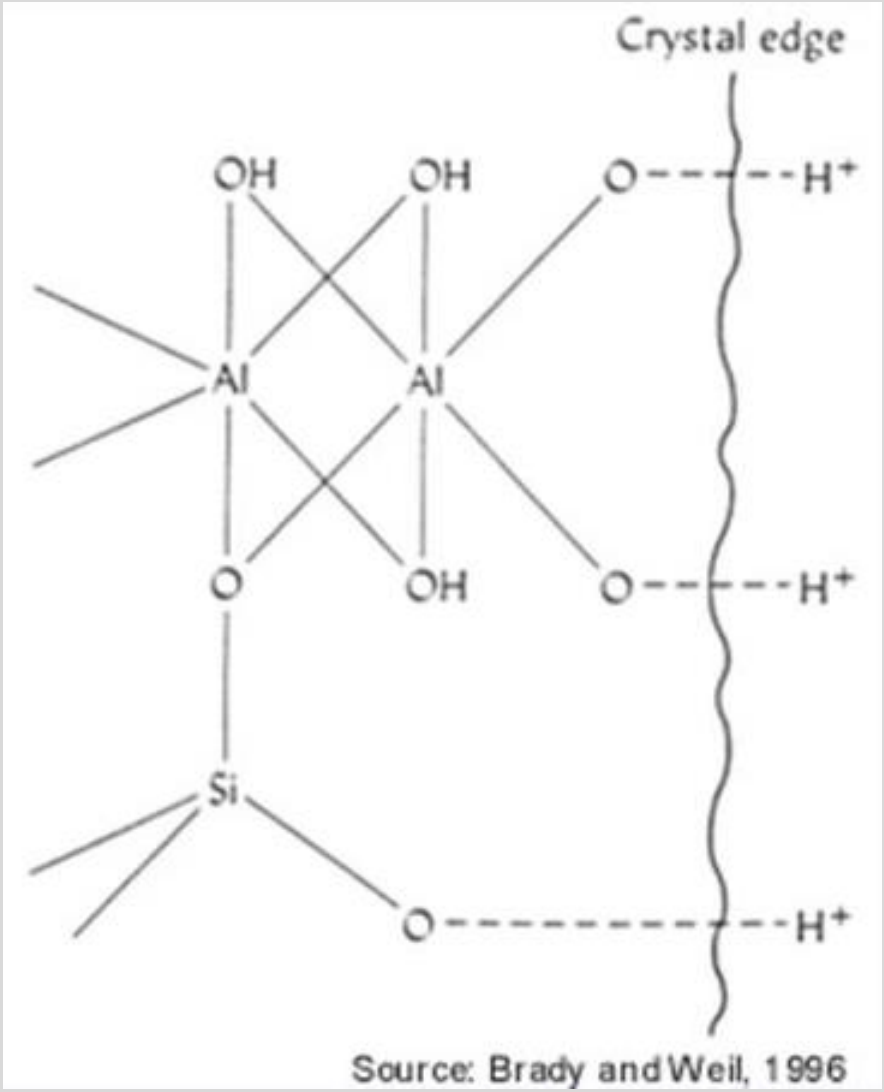



**Enol**




- Organic acids in the soils release $H^+$
- Holds onto other cations increasing reserve acidity

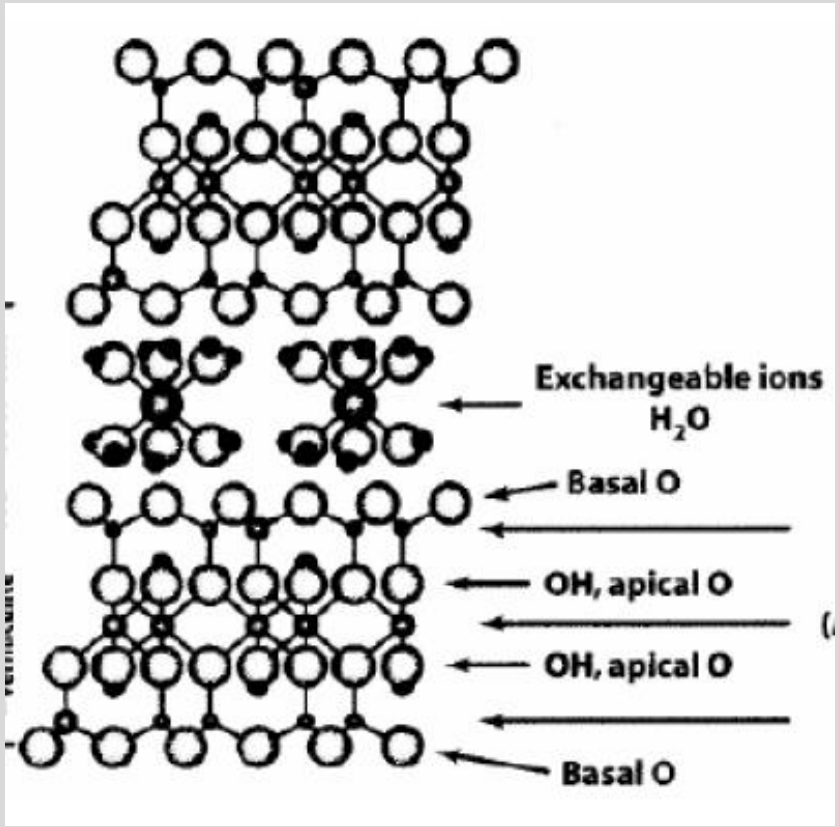
# Sources of reserve acidity



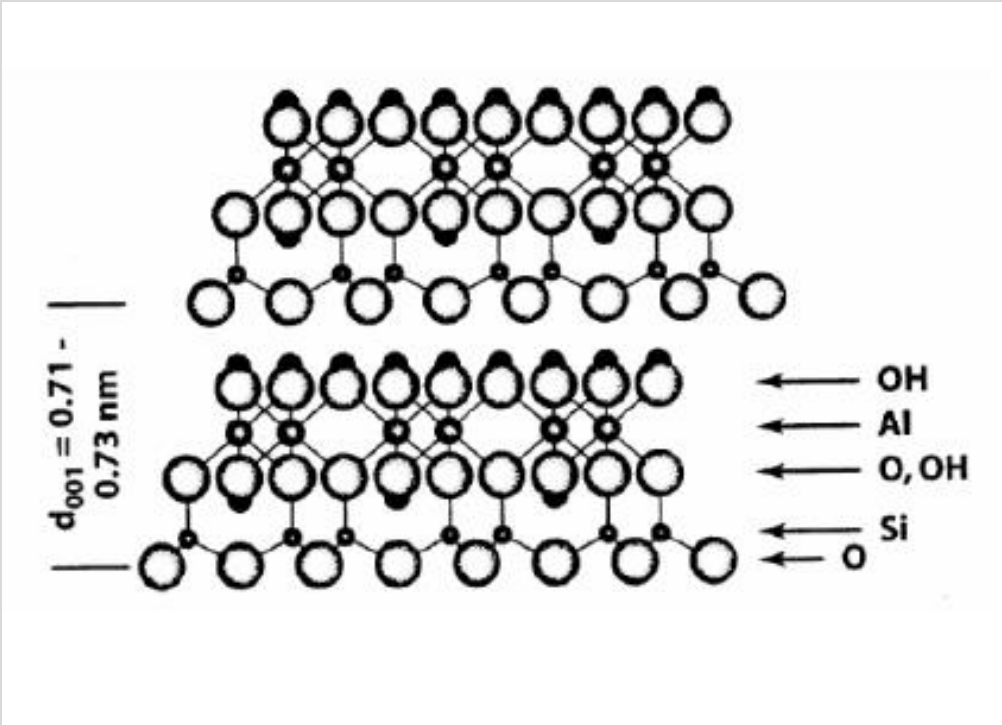

- Cation Exchange Capacity
  - Exchangeable $H^+$ and $Al^{3+}$ by cation exchange and hydrolysis
  - Varies by clay type

# Sources of reserve acidity

2:1 Soil Mineral i.e. Smectites




1:1 Soil Mineral i.e. Kaolinite



# Range in CEC depends on clay type

| Clay type | CEC (cmolc/kg) |
|---|---|
| Kaolinite | 1-10 |
| Mica, illite, and chlorite | 10-40 |
| Vermiculite | 100-200 |
| Smectite | 0-150 |
| Organic matter | 150+ |

Source: Essington

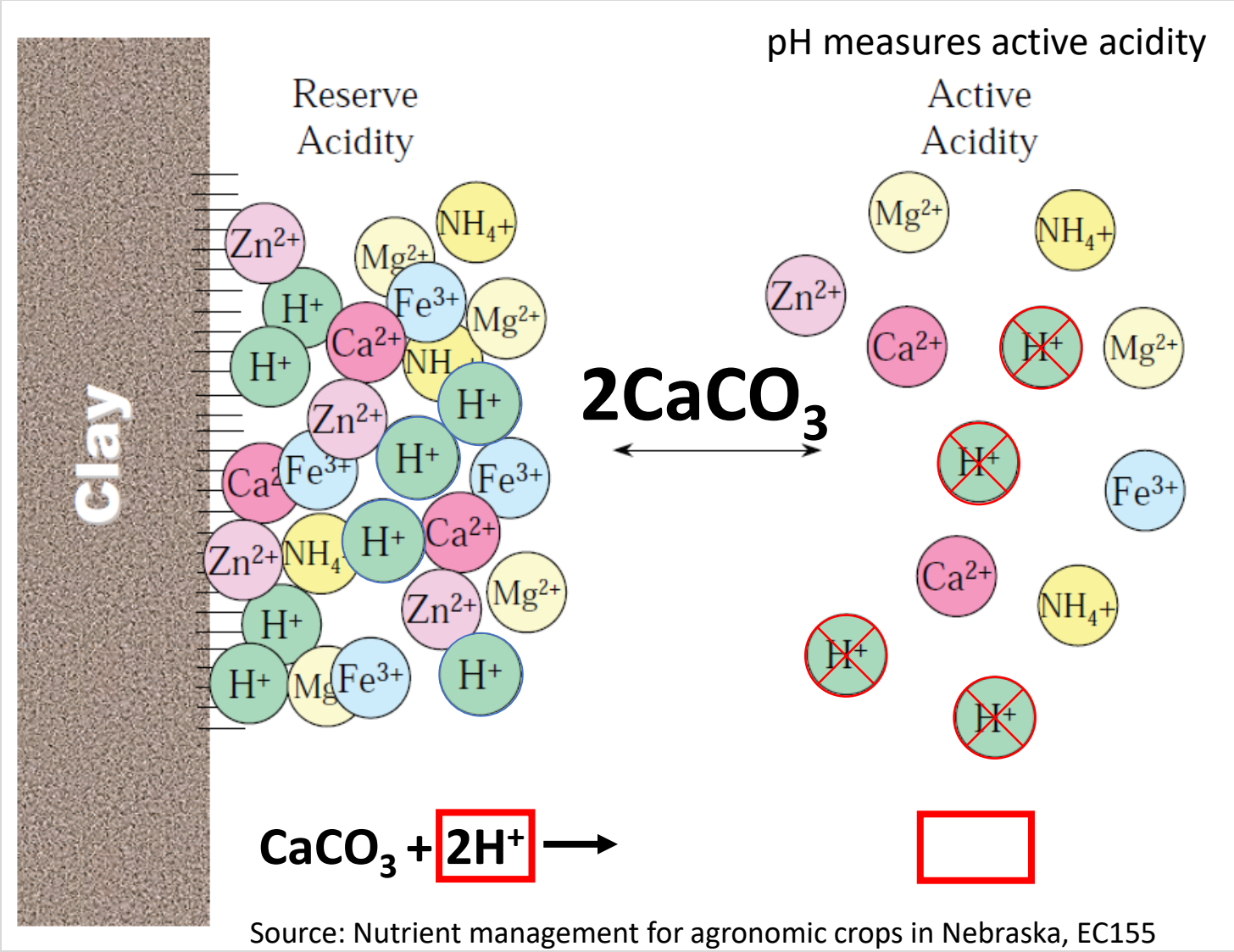
# CEC also varies by soil type

| Soil type | CEC (meg/100g) |
|---|---|
| Light colored **sands** | 3-5 |
| Dark colored **sands** | 10-20 |

Source: David Mengel Agronomy Guide AY-238 “Fundamentals of soil CEC”

# Step 2: Determine buffering capacity

Buffering capacity measures active + reserve acidity

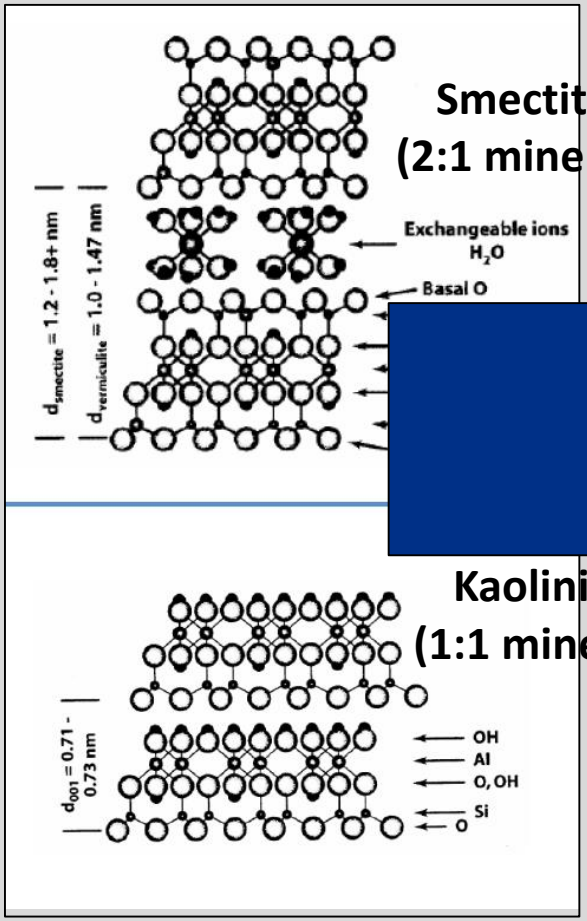



Source: Nutrient management for agronomic crops in Nebraska, EC155

# Step 2: Determine buffering capacity

Measurement of the reserve acidity varies by:

## Clay type



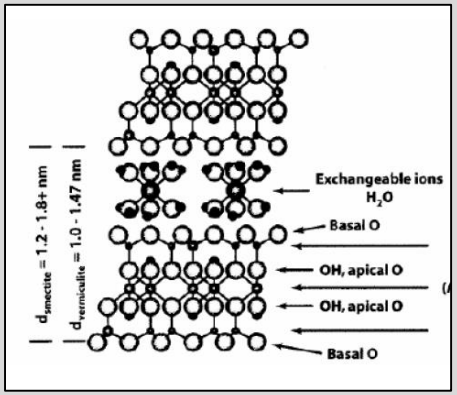

**CEC**

## Soil organic matter

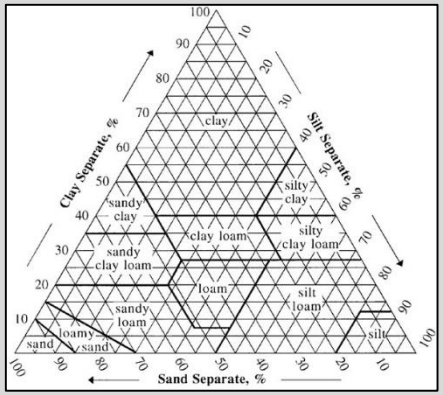
# Step 2: Determine buffering capacity

## Estimate

### CEC

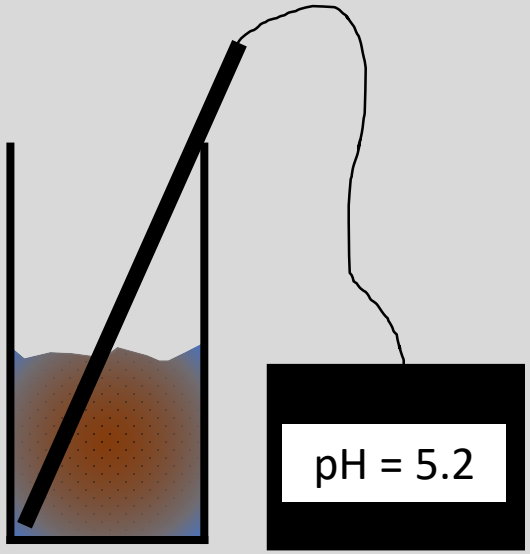



### Soil texture



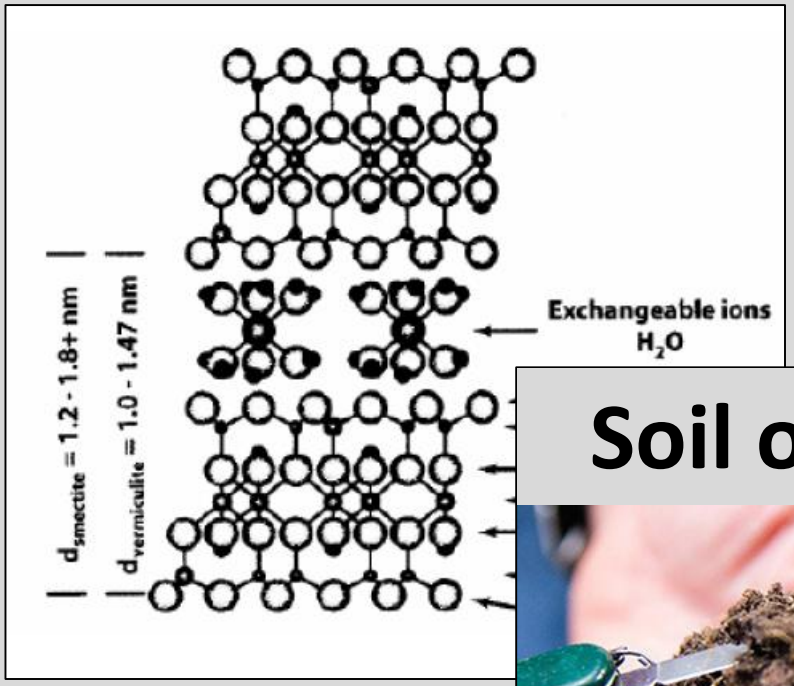

### Soil organic matter

## Direct measurement (Buffer pH)

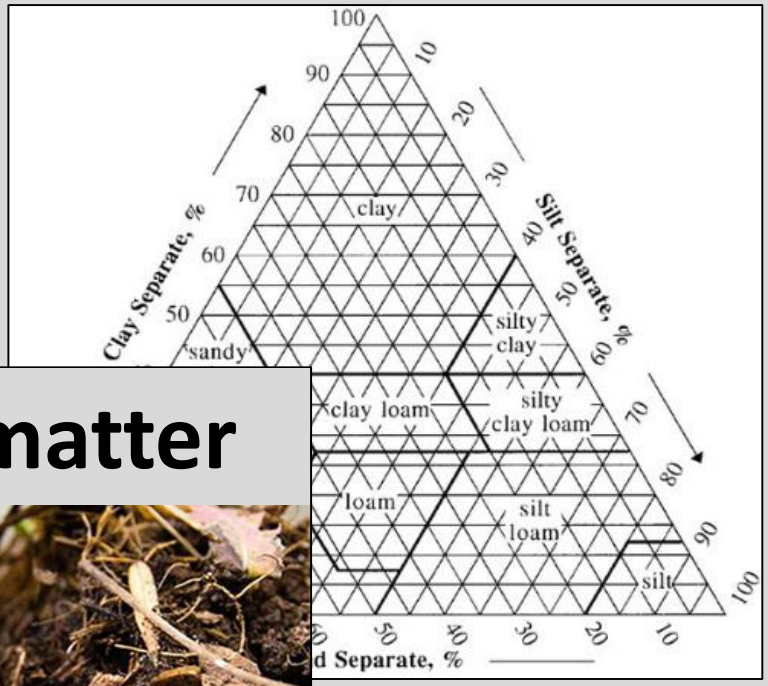


# Method 1: Estimate Buffering Capacity

## CEC




## Soil texture



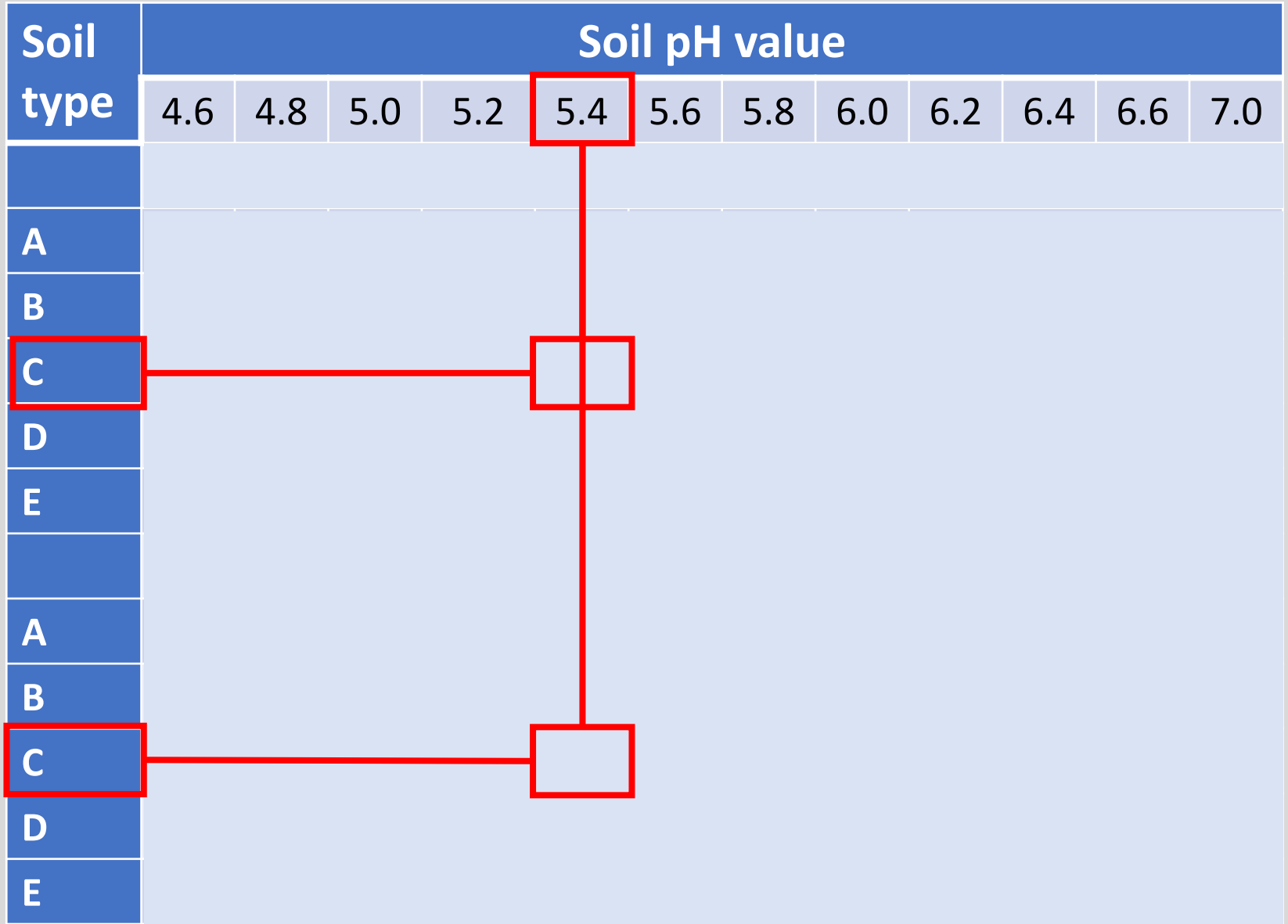

## Soil organic matter

# Step 2: Estimate buffering capacity

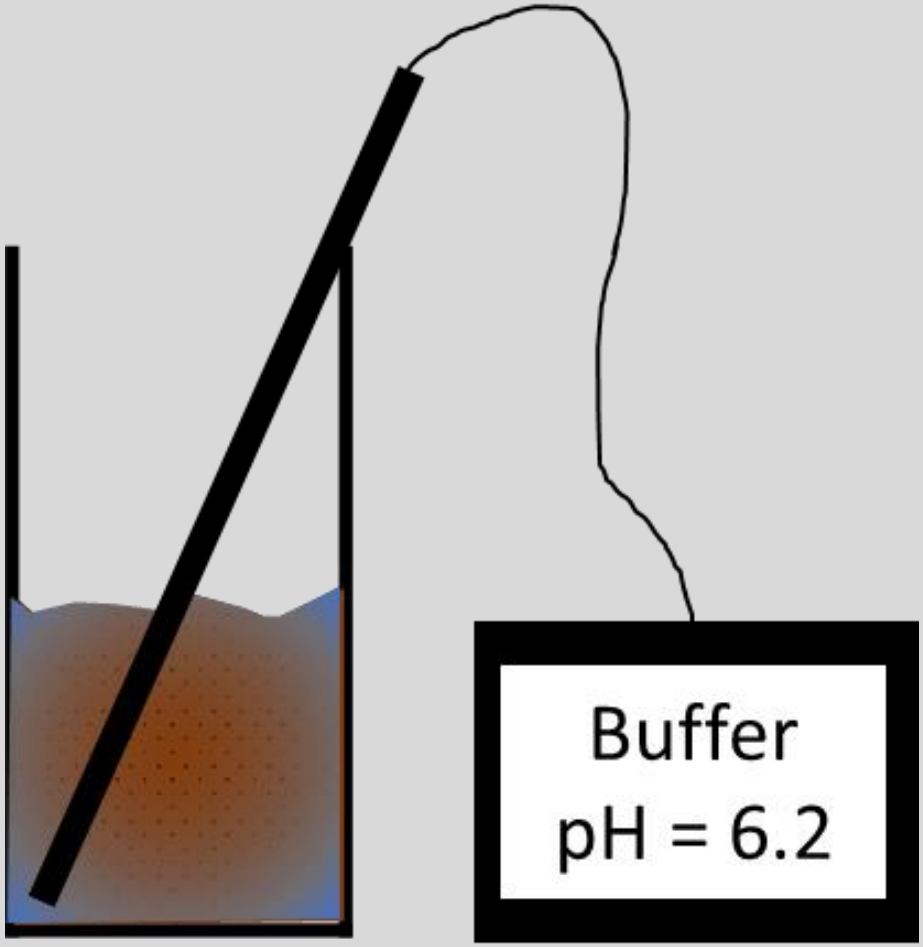
Estimate based on CEC, texture, and soil organic matter categories (Illinois)

- Soil color, soil texture, and CEC
- Soil color based on SOM:
  - light < 2.5%; Medium 2.5 – 4.5%; Dark > 4.5%
- **Soil A**: Dark-colored silty clays and silty clay loams (CEC > 24).
- **Soil B**: Light- and medium-colored silty clays and silty clay loams; dark-colored silt and clay loams (CEC 15–24).
- **Soil C**: Light- and medium-colored silt and clay loams; dark- and medium-colored loams; dark-colored sandy loams (CEC 8–15).
- **Soil D**: Light-colored loams; light- and medium-colored sandy loams; sands (CEC < 8).
- **Soil E**: Muck and peat. Soil color is usually related to organic matter. Light-colored soils 4.5% organic matter.

# Estimate based on CEC, texture, and soil organic matter categories (Illinois)



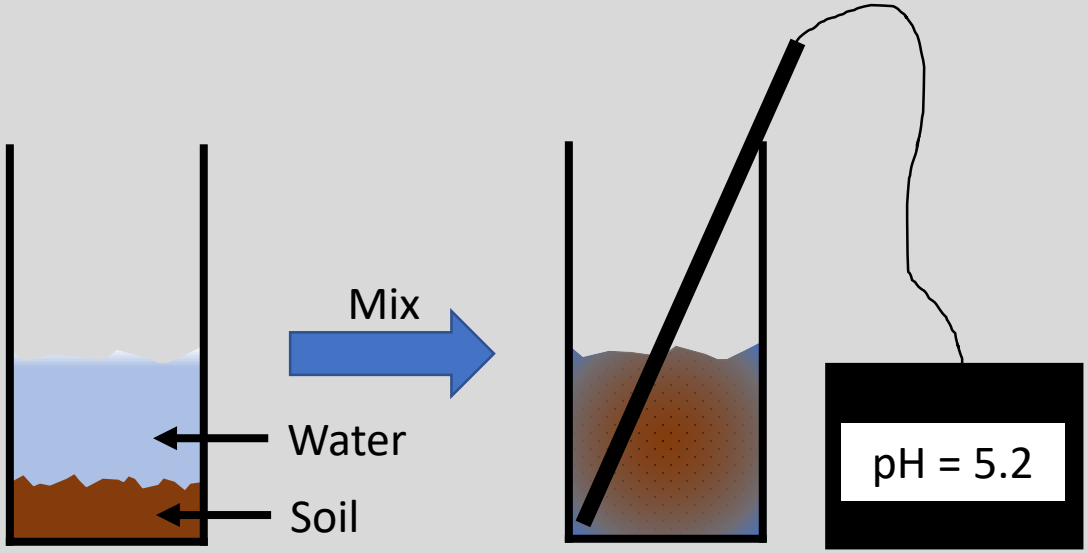
# Method 2: Measure Buffering capacity



# Step 2: Measure buffering capacity

Direct measurement

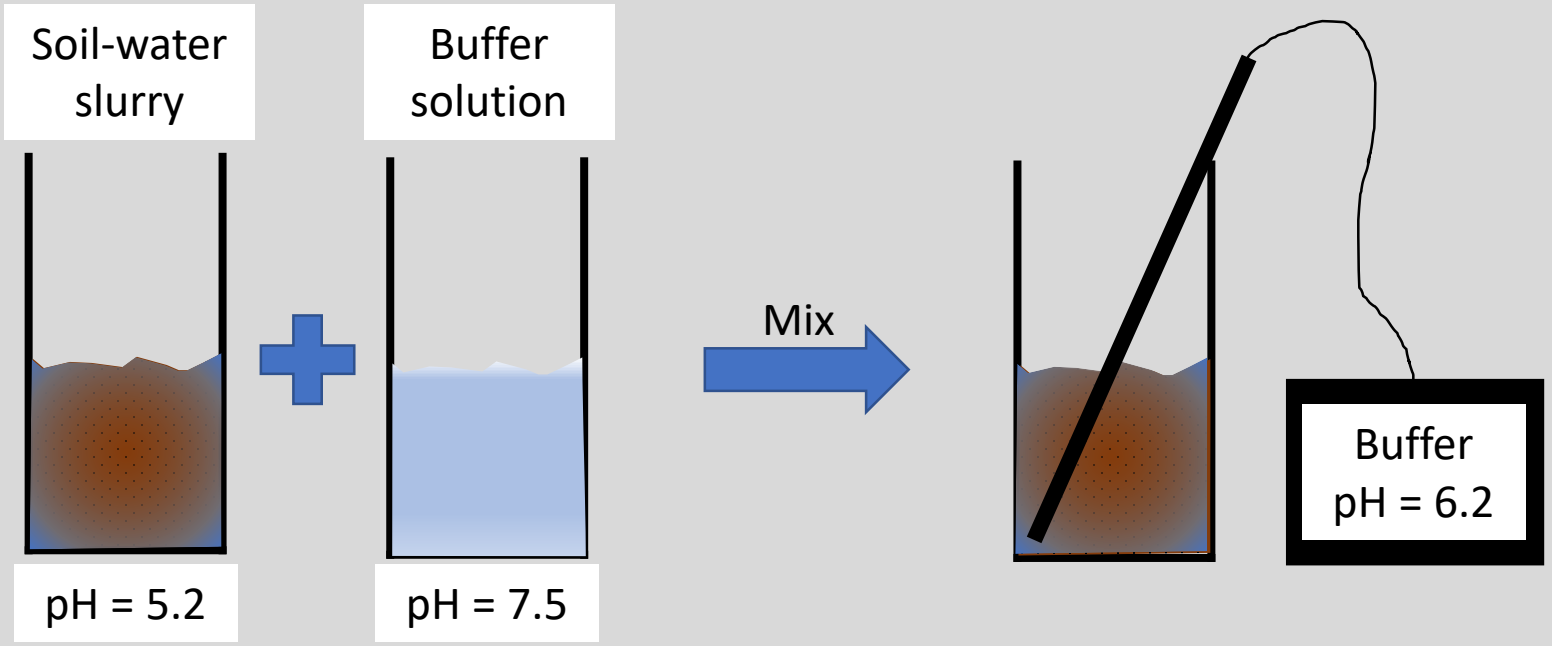
- Determine pH (soil:water)



# Step 2: Measure buffering capacity

Direct measurement

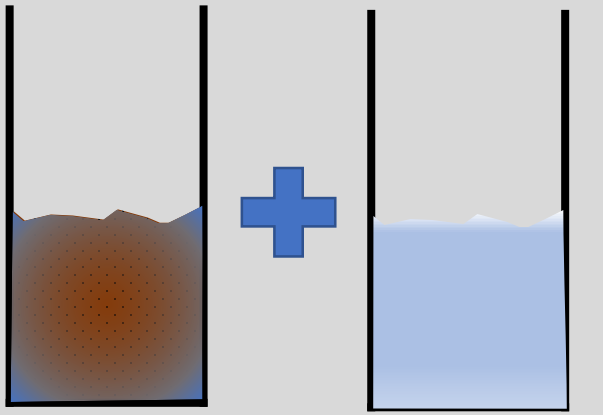
- Measure soil pH with a buffer
  - Buffer pH solution: Combination of chemicals that are formulated to change pH slowly with increased acidity.



**A.**

Soil-water slurry

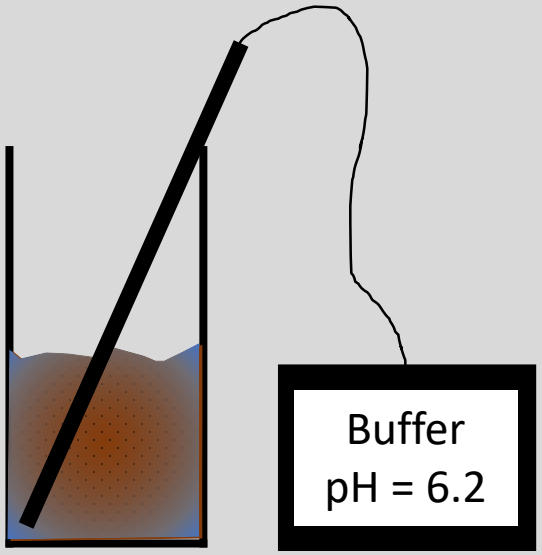
Buffer solution



pH = 4.7

pH = 7.5

Mix

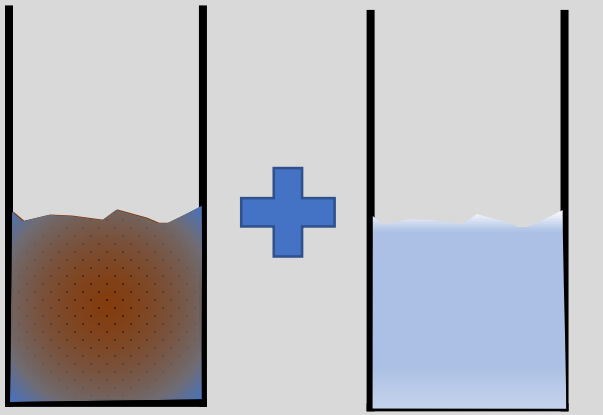



**How will this difference affect my liming rate?**

**B.**

Soil-water slurry

Buffer solution



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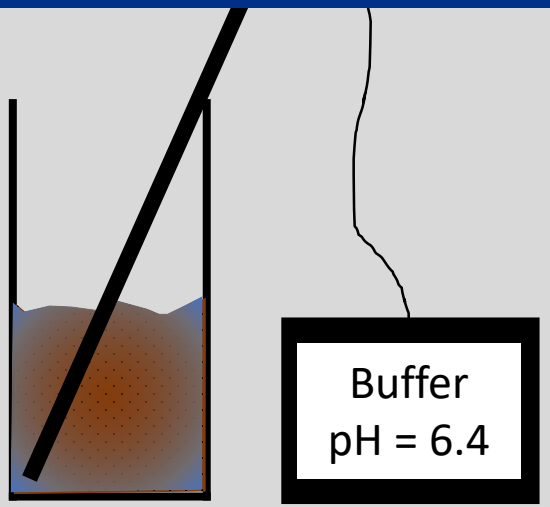

# Step 3: Determine the target pH

| Crop | MN; Raise pH to: | IA; Raise pH to: |
|---|---|---|
| Corn | 6.0 | 6.5 (low pH subsoil)<br>6.0 (high pH subsoil) |
| Soybean | 6.0 | 6.5 (low pH subsoil)<br>6.0 (high pH subsoil) |
| Wheat | 6.0 | |
| Oats | 6.0 | |
| Barley | 6.0 | |
| Sunflower | 6.0 | |
| Sorghum | 6.0 | |
| Alfalfa | 6.5 | 6.9 |

# Step 4: Determine lime rate using soil's buffer pH and target pH (South Dakota)

| Buffer pH | Lime requirement to raise pH to 6.0: 0-6 in. (tons/ac) |
|---|---|
| > 6.5 | 0 |
| 6.2 – 6.5 | 2.0 |
| 5.9 – 6.2 | 2.5 |
| 5.6 – 5.9 | 3.0 |
| < 5.6 | 3.5 |

*Based on 90% $CaCO_3$ equivalent and 70% effectiveness

# Step 4: Determine lime rate using soil's buffer pH and target pH (Iowa)

| | Target soil pH | | |
|---|---|---|---|
| **Buffer pH** | 6.0 | 6.5 | 6.9 |
| | Amount of $CaCO_3$ to apply (lbs./ac) | | |
| **7.0** | 0 | 0 | 1,100 |
| **6.8** | 0 | 600 | 2,700 |
| **6.6** | 0 | 2,100 | 4,400 |
| **6.4** | 800 | 3,500 | 6,000 |
| **6.2** | 2,000 | 5,000 | 7,700 |
| **6.0** | 3,100 | 6,400 | 9,300 |
| **5.8** | 4,300 | 7,900 | 11,000 |

Source: Mallarino, Sawyer, and Barnhart. 2013. A General guide for crop nutrient and limestone recommendations in Iowa. Iowa State University.

# Estimating vs. measuring buffering capacity

Estimate based on CEC, texture, and soil organic matter

**OR**

Measure with buffer pH

| Soil Texture | CEC (meq/100g) | Soil pH | Buffer pH | Lime requirement (t/ac) |
|---|---|---|---|---|
| Loamy sand | 6 | 5.6 | 6.8 | 1 |
| Silt loam | 14 | 5.5 | 6.6 | 2 |
| Silty clay loam | 24 | 5.6 | 6.2 | 4 |

Source: Wortman et al. 2014. EC155 UNL Extension

# Thank You!

Picture: www.braenstone.com/agricultural-lime/

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