700 different soils in WI
Productive soil must be fertile

• physical fertility
  – texture, structure, drainage, tilth

• chemical fertility
  – nutrient supply
    • soil testing
THE SOIL COMPOSITION

SILT LOAM TOP SOIL

ORGANIC 0.5-5%

AIR 25%

WATER 25%

MINERAL 45-50%
Soil formation-’weathering’

- physical
  - freezing, thawing, wetting, drying, organisms
- chemical
  - dissolved minerals moved in water
  - soil horizons formed
- 1 inch - 100 years
Why soils are different from each other
Ap (plow layer)
A2 (leached layer)
B2 (layer of accumulation clay, iron, etc.)
C (parent material)
Plants and parent material affect how soils form.

Soil Formation:

Typic Quartzipsamment
Boone loamy sand

Typic Eutrochrept
Salter silt loam

Typic Argiudoll
Tama silt loam
Soil texture

- classes - sand, silt, clay
  - names based on proportions
    - loam, silty clay, loamy sand
    - changing proportions not recommended
- clay also group of minerals
  - montmorillonite, kaolinite,
- nutrient storehouse
Soil Minerals

Silt
Clay
Very fine sand
Fine sand

Coarse sand
Sand

NOTE: LARGEST CIRCLE HAS ABOUT SAME ACTUAL DIAMETER AS PENCIL LEAD (1 MILLIMETER).
Soil organic matter

- plants, animals, microorganisms
  - living, dead, decay products
  - humus
    - complex, dark-colored, reactive
- soil acidity reservoir
- nutrient storehouse
Soil structure

• particles ‘glued’ into aggregates
  – organic matter, clay, bacterial secretions, Fe/Al oxide coatings
  • granular, platy, blocky
  – finer aggregates in ‘topsoil’, massive in subsoil
• improve by adding organic residues
  – decay: 90% CO₂ + H₂O
**PLATELIKE**
- PLATY
  - Leafy and flaky
  - Also found

**PRISMLIKE**
- PRISMATIC
  - (Level tops)
- COLUMNAR
  - (Rounded tops)

**BLOCKLIKE**
- BLOCKY
  - (Cubelike)
- BLOCKY
  - (Subangular)
- GRANULAR
  - (Porous)
- CRUMB
  - (Very porous)

**SPHEROIDAL**

- May occur in any part of profile. At times inherited from the soil material.

- Both usually subsoil manifestations. Common in soils of arid and semiarid regions.

- Common in heavy subsoils, particularly those of humid regions.

- Characteristic of the furrow slice. Subject to wide and rapid changes.
Problem: ‘heavy’ soil

• aggregates tightly packed
  – small pores
    • poor drainage, roots suffocate
  – ‘cloddy’ if tilled wet
    – compacts easily
• improve with organic residues
  – better crumb stability, larger pores
  – larger pores
    • sand + clay = cement
Problem: ‘light’ soil

• aggregates too big to pack tightly
  – large pore spaces
  – droughty
• improve with organic residues
  – ‘sponge’
Organic residues

• compost, grass clippings, crop residues
  – annual gardens - 1 bu / 20 sq ft
  – perennial gardens - 1 bu / 10 ft
  • do not add to tree/shrub planting hole
• green manure, fall cover crops
  – green topgrowth tilled under
• extra N needed if high C residue
  – microorganisms ‘tie-up’ N
  • wood chips, sawdust, oat straw
Organic residues

- provides ‘food’ for microorganisms
  - for every 100 lb. added, 90 lb. converted to water, carbon dioxide
    - 10 lb. stable 1st year
    - 1 lb. stable 2nd year
  - microbial decay process
    - more ‘cement’ for better crumb stability
    - nutrients released
    - fresh surfaces for nutrient holding
**Nutrient supply**

- clay main ‘nutrient storehouse’
  - negative charge
  - attracts, holds positive ions
    - $\text{Ca}^{++}$, $\text{Mg}^{++}$, $K^+$, $\text{NH}_4^+$
- easily displaced, exchanged
  - plant uptake
CEC, Whether Large or Small

AFFECTS:

1. Capacity to hold nutrients such as Ca, Mg, and NH$_4$-nitrogen

2. Quantity of a nutrient needed to change its relative level in soils
Nutrient supply: other sources

• Al, Fe and/or Ca compounds
  – phosphate fixed
  – recovery of fertilizer P < 30%

• organic matter
  – N, S, trace elements

• soil solution
  – NO$_3^-$, Cl$^-$, SO$_4^{2-}$
#### Essential Elements for PLANTS

**AIR, WATER**
- C carbon
- H hydrogen
- O oxygen

**SOIL**
- N nitrogen
- P phosphorus
- K potassium
- Ca calcium
- Mg magnesium
- S sulphur
- Cl chlorine
- B boron
- Cu copper
- Fe iron
- Mn manganese
- Mo molybdenum
- Zn zinc
Food for plants?

- plant, animal nutrition very different
  - plants manufacture basics
    - protein, carbohydrate, sugar….
    - 13 essential soil elements
      - N, P, K - primary
      - Ca, Mg, S - secondary
      - B, Cl, Cu, Fe, Mn, Mo, Zn – trace
  - animals eat basics
Soil Testing:
• sampling
• laboratory testing
• interpretations/recommendations
Soil test

- rapid chemical analysis
- index of potential nutrient supply
  - deficiency
  - excess
- sample to show ‘true’ variation
  - composiate
Sampling soils

- sample depth
  - established turf - 4 inches
  - new turf, gardens - 6 inches or tillage depth
  - raised beds - depth of bed
  - probe best, spade OK

- combine 5 subsamples – composiate
Avoid unusual areas: backfill, wet spots, etc.
Combine 5 subsamples for composiate
Sampling soils

- when
  - annual gardens, new turf
    - fall, spring before tillage
  - perennials, problems, established turf
    - anytime
  - suspected salt damage
    - very early spring
- sample each area separately
  - repeat every 2-3 yrs
Useful laboratory tests

• routine
  – soil pH, ‘buffer’ pH
  – organic matter %
  – available P and K
  • no good test/need for N, Ca, Mg, S, B, Zn, Mn, Fe, Cu, Mo
• ‘problem solving’
  – texture, soluble salts, Cl, Pb, As,...
Soil test report

- potential for deficiency
- which nutrient needed
- how much to apply
  - fertilizer for nutrient need
  - lime, sulfur amendments for pH change
- when to apply
- when to STOP!
Yield response to nutrient additions

Relative Yield

Relative amount of nutrient applied

Soil Test
- High
- Optimum
- Low
HIGH SOIL TEST
Less Nutrients Needed From Fertilizer

LOW SOIL TEST
More Nutrients Needed From Fertilizer
Soil test results

• excessively high
  – common for residential areas
  – not detrimental
  – adding more not beneficial
  – avoid balanced blends, most organics

• low
  – build to optimum
    • turf fertilizer blends
Soil test results - pH

- measure of acidity, alkalinity
  - scale 1 - 14, optimum 6 - 7+
- add lime only if recommended
  - incorporate 6 - 8 inches
- add aluminum sulfate to acidify
  - new turf
    - if strongly alkaline
      - blueberry, rhododendron
Effect of soil pH on nutrient availability
**Optimum pH for turf**

- depends on species**
  - kentucky bluegrass 6.0 - 7.6
  - annual bluegrass 5.1 - 7.5
  - creeping red fescue 5.3 - 7.5
  - bentgrass 5.3 - 7.5
  - ryegrass 5.4 - 8.1

**Musser, 1982**
Soil test results - organic matter

• 2 - 4% most soils
  – impractical, difficult to change
• nutrient reservoir
• basis for N rec
Soil test results - N

• promotes leaf growth
• no direct measures on report
  – N rec from crop need, organic matter
• excess N
  – delays maturity
  – moves below root zone
Soil test results - P

- stimulates root growth and flowering
  - shallow rooted greater need
- optimum soil test P for turf
  at planting
    - seed 31 - 45 ppm
    - sod 21 - 30 ppm
  established 11 - 15 ppm
Soil test results - K

• promotes disease resistance, winter hardiness
  – root crops require most
  – optimum soil test K for turf
    at planting
    – seed all levels OK
    – sod all levels OK
  established 41 - 60 ppm
Inorganic fertilizer

- chemically simple
  - N in air plus water/fossil fuel
  - rock phosphate, potash mined, sized and cleaned
    - handling improved
      - clay, diatomaceous earth added
    - TSP from added acid
- very soluble, easily blended
<table>
<thead>
<tr>
<th>Type</th>
<th>Nutrient</th>
<th></th>
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<tbody>
<tr>
<td></td>
<td>N</td>
<td>P$_2$O$_5$</td>
<td>K$_2$O</td>
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<tr>
<td>urea</td>
<td>46</td>
<td>0</td>
<td>0</td>
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<tr>
<td>ammonium nitrate</td>
<td>33</td>
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<td>0</td>
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<tr>
<td>triple super P</td>
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<td>46</td>
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<tr>
<td>ordinary super P</td>
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<tr>
<td>muriate of potash</td>
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<td>0</td>
<td>60</td>
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<tr>
<td>potassium sulfate</td>
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<td>0</td>
<td>50</td>
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</tbody>
</table>
**Recommended fertilizer - turf blends**

- **regular or maintenance** - ‘high N’
  - soil test P, K optimum, above
- **starter** - ‘high P$_2$O$_5$’
  - soil test P below optimum
- **winterizer** - ‘high K$_2$O’
  - soil test K below optimum
Organic fertilizer

• chemically complex, contains C
  – naturally occurring
  – byproducts
• microorganisms must degrade
  – slow release, rate ???
• improve structure with long-term use
## Organic fertilizer

<table>
<thead>
<tr>
<th>Type</th>
<th>N</th>
<th>P$_2$O$_5$</th>
<th>K$_2$O</th>
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<tbody>
<tr>
<td>blood meal</td>
<td>13.0</td>
<td>1.5</td>
<td>0.6</td>
</tr>
<tr>
<td>bone meal, steam</td>
<td>2.2</td>
<td>27.0</td>
<td>0</td>
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<tr>
<td>seaweed</td>
<td>1.5</td>
<td>1.0</td>
<td>4.9</td>
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<tr>
<td>tree leaves</td>
<td>0.7</td>
<td>0.1</td>
<td>0.8</td>
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<tr>
<td>greensand</td>
<td>0</td>
<td>1.4</td>
<td>6.3</td>
</tr>
<tr>
<td>activated sewage s.</td>
<td>6.0</td>
<td>3.0</td>
<td>0.2</td>
</tr>
</tbody>
</table>
Organic fertilizer

• may contain
  – unnecessary nutrients, compounds
  – nonessential elements

• does not add nutrition nor improve flavor
Foliar sprays: fruits, sensitive ornamentals

- trace, secondary elements
  - soil Fe, Mn ‘fixed’ at high soil pH
  - supply by spraying leaves
  - temporary ‘fix’, requires repeating

- emergenies
  - no substitute for soil applied nutrients
    - leaf burn, expensive, extra work
    - most spray falls on soil
I'VE GOT PLENTY OF COMMON SENSE!

I JUST CHOOSE TO IGNORE IT.
Product claims

- Peters Fertilizer 20 - 20 - 20
  - all purpose
  - dissolves completely in water and will not settle out
  - free of excess soluble salts
  - very safe, nonburning
  - contains proper trace elements
**Product claims**

- Neptune's Harvest **2 - 4 - 0.5**
  - 100% liquid fish food
  - Made from N. Atlantic fish, cold process
  - All nutrients intact, chelated
  - Contains vitamins, minerals, macro- and micronutrients, amino acids, trace elements, growth hormones
  - Builds healthier soils by aiding bacteria and other organisms which support healthier plants
Product claims

- Alaska Fish Fertilizer 5 - 1 - 1
  - made from ocean fish
  - no chemical amendments to increase nutritional content
  - over 19 different trace elements
  - 11 different vitamins, especially B
  - amino acids naturally occurring are more readily available to plants than other N forms
Product claims

• Eleanor's VR 0.15 - 0.85 - 0.55
  – ‘seems like magic’
  – use VR-11 safely on any plant and expect immediate improvement
  – aids blossoming, promotes lush fern growth, vigorous growth in creeping plants
  – only Eleanor knows the ‘magic’ ingredients
**Product claims**

- **Granite Meal 0 - 0 - 3**
  - pulverized granite rock
  - some growers criticize it as too slow releasing, others praise its gentle breakdown rate
  - contains 67% silica, trace elements
  - silica plays important role in soil fertility
Product claims

• Greensand 0 - 1 - 6
  – mined sea deposit has a pleasant odor and is hefty enough not to get blown away
  – the greener it is, the more potassium it has
  – contains 50% silica, 18 - 20% iron oxide and 22 trace elements
  – loosens clay soil and prolongs flower bloom
**Product claims**

- **Lonfosco Soft Rock Phosphate 0 -16 -0**
  - soft, natural colloidal clay - a form most usable by crops
  - has 27% calcium plus 18 essential trace elements
  - unlike chemically treated phosphates, its insoluble in water and lasts in soil without leaching for years
Product claims

• Harvest Alive!
  – highly concentrated complete liquid organic foliar plant food
  – made with a unique digestive process from plant and animal manures
  – ‘super manure tea’ made from concentrated essential minerals, cytokinius, vitamins and amino acids
  – does not replace regular fertilizer, but provides benefits beyond scope of conventional plant food
Product claims

- Mother Natures Worm Castings
  – odorless excrement of earthworms
  – unique in versatility as fertilizer, soil amendment, plant food, propagating medium
  – chemical evaluation shows high to very high phosphorus, potassium, calcium, magnesium, and nitrates
Product claims

• **ERTH-RITE**
  – introduces friendly bacteria essential for soil improvement
  – careful combination of animal, mineral, plant and marine products
  – major and trace elements for proper plant growth
  – helps fix N, loosen soils, release tied-up elements and much more
Product claims

- SUPERthrive
  - formula contains 50 vitamins, hormones
  - indoor plants helped to survive low light, great equalizer for over/under watering
  - nontoxic solution containing crystalline compounds of C, H, O
  - given enough time, your plant will produce all of these by itself--but can get all they need now!
an EXTENSION program of the UW-MADISON

College of Agricultural and Life Sciences