From “dirt”….

…to “soil”.

Man—despite his artistic pretensions, his sophistication, and his many accomplishments—owes his existence to a six-inch layer of topsoil….

….and the fact that it rains.

- Author Unknown

And just a couple ‘o plants!

And a little sun….
There are 700 different soils in Wisconsin.

**Soil is**

- Parent material + bedrock
- Decaying vegetation

Influenced by:
- climate
- relief
- time
- organisms

**What is soil?**

- A Horizon
- B Horizon
- C Horizon

And what you do with them!
Wisconsin’s State Soil: Antigo Silt Loam

Soil Physical Features
- Texture
- Structure
- Air
- Water
- Organic matter

Soil Texture
- classes - sand, silt, clay
- names based on proportions
  - loam,
  - silty clay
  - loamy sand

Clay Soil
- 10 - 30% Clay
- 30 - 50% Silt
- 20 - 50% Sand

Loam Soil
- 50 - 100% Clay
- 0 - 45% Silt
- 0 - 45% Sand
Soil Structure

Soil Water

Soil Aeration

“Ventilation”
Organisms

The Ideal Soil

- pH
- Cation Exchange Capacity
- nutrients

Soil Chemical Features
Soil pH

- Range of pH common for humid-region soils
- Range in pH for arid-region soils
- Range in pH for most inorganic soils

Lime Lifts pH (less acidic)
Sulfur Suppresses pH (more acidic)

Cation Exchange Capacity
Quantifies the ability of a soil to provide a nutrient reserve for plant uptake
Soil Management

**• Improve Texture**
  - Amendments

**• Preserve Structure**
  - Cultural practices

**• Balance Air & Water**
  - Aeration
  - Water-holding capacity

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Amendments

- **Organic matter**
  - Formerly living materials
  - Improve texture & structure
  - Add pore space
  - Improves water-holding and nutrient-holding

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NEVER ADD SAND!

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Examples

- Peat
- Leaf mold
- Mulches
- Compost

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Compost
What is Compost?

• Material left after the aerobic decomposition of organic material(s)

\[
\text{Organic Material} + \text{“bugs”} + O_2 \rightarrow \text{Compost} + CO_2 + H_2O
\]

Why Compost?

• Save Money
• Improve soil structure
• Improve plant growth
• Benefit the environment

How to make compost

• Bacteria do most of the work!
  – Bacteria break down fresh organic residues into compost using oxygen
  – Process generates a lot of heat
    • Up to 140 degrees F!
    • Heat kills weed seeds and diseases

• You need to:
  1. Add the right balance of Carbon and Nitrogen (Browns and Greens)
  2. Turn the pile to improve oxygen flow
  3. Maintain a good moisture content (not too wet, not too dry)

“Equal Weights of Green & Brown...”
(Or 1:2 Parts Brown to 1 Part Green)

<table>
<thead>
<tr>
<th>Browns (Carbon)</th>
<th>Greens (Nitrogen)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dried leaves</td>
<td>Fresh Grass Clippings</td>
</tr>
<tr>
<td>Paper</td>
<td>Fruit and Veggie Scraps</td>
</tr>
<tr>
<td>Cardboard</td>
<td>Manure (no pet waste)</td>
</tr>
<tr>
<td>Sawdust</td>
<td>Fur, hair, fibers, feathers</td>
</tr>
<tr>
<td>Wood ash twigs</td>
<td></td>
</tr>
</tbody>
</table>
Turning the pile

- Turn don’t stir
- Improves oxygen, keeps the process moving
**Do Not Compost**
- Meat, bones, fat
- Cat, dog, human waste
- Dairy products
- Charcoal ash
- Oils
- Thorny twigs
- Logs or large branches
- Sawdust from treated lumber
- Poison ivy

**Troubleshooting**

<table>
<thead>
<tr>
<th>Problem</th>
<th>Observation</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Too dry</td>
<td>Dry or cracks to the touch</td>
<td>Add water, keep pile as damp as a wrung out sponge</td>
</tr>
<tr>
<td>Too wet</td>
<td>Soggy, may smell</td>
<td>Turn pile, stop watering</td>
</tr>
<tr>
<td>All green</td>
<td>Pile matted, Smells bad</td>
<td>Turn pile, add brown</td>
</tr>
<tr>
<td>Greasy</td>
<td>Pile matted, smells bad, attracting varmints</td>
<td>Remove meat, fat and oils</td>
</tr>
<tr>
<td>Too slow</td>
<td>Doesn’t heat up</td>
<td>Add more greens</td>
</tr>
</tbody>
</table>

**When is the compost done?**
- Original material is difficult to identify
- Few fibers left
- Smells like soil, or earth
- The pile is cool for at least 1 month
- Crumbly not slimy

**How long does it take?**
- Depends on material, moisture content, and how often you turn
  - Anywhere from 6 weeks to 1 year
- “Cold” Composting
  - No turning, just pile it up and scoop out finished compost from the bottom of the pile
  - 1 – 2 years
Using Compost
- Amend over a site, never amend a hole
- Incorporate at least 25-50% by volume of a well-composted organic matter source
- Work in to a depth of at least 12-18 inches
- Be sure that excess water in soil can drain
  - Sufficient topography to drain water
  - Use French drains where appropriate
  - Install sub-surface drainage just above unamended soil

Apply an even layer of o.m. and work it into “the top 4 - 6 inches”

Preserve Structure
- Never work wet soil

Avoid over tillling

Avoid compacting soil

Avoid Excess De-icing Salt
**Nutrients**

- Fertilizer provides nutrients so plants can make their own food

**Nutrients**

- Come from the soil
  - Dissolved in water
  - Taken up by plant roots
  - Very little by leaves

---

**17 Plant Essential Elements**

<table>
<thead>
<tr>
<th>Hydrogen, Oxygen, Carbon</th>
<th>Nitrogen, Phosphorus, Potassium (K)</th>
<th>Magnesium, Calcium, Iron, Sulfur, Boron, Zinc, Manganese, Molybdenum, Copper, Chloride, Nickel</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Essential and Beneficial Elements in Higher Plants</th>
<th>Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Essential Mineral Element</td>
<td>B</td>
</tr>
<tr>
<td>Benign Mineral Element</td>
<td>C</td>
</tr>
<tr>
<td>Essential Nonmetal Element</td>
<td>N</td>
</tr>
<tr>
<td>Important Nonmetal Element</td>
<td>O</td>
</tr>
<tr>
<td>Essential Macroelement</td>
<td>F</td>
</tr>
<tr>
<td>Essential Micrometal Element</td>
<td>Ne</td>
</tr>
</tbody>
</table>

**How to remember the 17 essential elements**

C HOPKINS CaFe is Mighty Nice, But Many More Prefer Clara's Zany Cup

- Required for the plant to complete life cycle
- Directly involved in metabolism
- Can not be substituted by another nutrient
- Essential for a wide range of plants

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**Inadequate nutrient supply leads to deficiency symptoms (plant illness)**

Each nutrient deficiency is expressed differently

If significant a deficiency can lead to plant death

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**Soil testing tells us**

- Plant available Phosphorus
- Plant available Potassium (K)
- Percent organic matter
- Soil pH
- Estimated texture

**Soil testing is the only preplant method of knowing nutrient need**
A shovel is OK too, mix a small amount in a clean bucket

Walk a “W”

In Minnesota, Maine, Missouri….

Sampling soils
• when
  – annual gardens, new turf
    • fall, spring before tillage
  – perennials, problems, established turf
    • anytime
  – suspected with 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
• other
  – Ca, Mg, S, Zn, B, Mn
  – no good test/need
  – N, Fe, Cu, Cl, Mo, Ni
• ‘problem solving’
  – texture, soluble salts
  – Cl, Pb, As,…

Soil test results - P
• stimulates root growth and flowering
  – shallow rooted greater need
• optimum soil test P for turf and gardens
  – established turf
    • 11 - 15 ppm
  – sweet corn
    • 15 - 25 ppm
  – green bean
    • 15 - 25 ppm
  – tomato
    • 31 - 45 ppm
  – potato
    • 161 - 200 ppm

 UW Soil and Plant Analysis Lab
  8452 Mineral Point Rd, Verona 53593
  (West Madison Ag. Research Station)
Soil test results - K

- promotes disease resistance, winter hardiness
  - root crops require most
  - optimum soil test K for turf and gardens

  - established turf: 41 - 60 ppm
  - sweet corn: 101 - 120 ppm
  - green bean: 131 - 160 ppm
  - tomato: 131 - 180 ppm
  - potato: 121 - 160 ppm

Fertilizers provide nutrients

Fertilizer Features

- Analysis
- Grade
- Formulation
- Source
  - Organic
  - Inorganic

Analysis is the percentage of nutrients contained per pound of product

Grade

- Mixed grade
  - Contains all 3 major nutrients

- Single or low grade
  - Contains only one or two
    - Potash
    - Superphosphate

Milorganite 6-2-0
Fertilizer Formulations

- Liquid – drench
- Soluble – drench
- Granular – Broadcast, side-dress, banded
- Slow-release – incorporate
- Solid – spikes – insert

Applying Fertilizers

Organic fertilizer

- Nutrients in complex molecules
  - Need to decompose to release
  - Slow release
  - Low “burn” potential
- Very low analysis
- Adds organic matter – Primary benefit
- Often more expensive per pound of nutrient - unless its free!
Organic fertilizer

<table>
<thead>
<tr>
<th>Type</th>
<th>N</th>
<th>P2O5</th>
<th>K2O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cow manure</td>
<td>2.1</td>
<td>3.2</td>
<td>3.0</td>
</tr>
<tr>
<td>Horse</td>
<td>0.6</td>
<td>0.3</td>
<td>0.5</td>
</tr>
<tr>
<td>Chicken</td>
<td>1.6</td>
<td>1.8</td>
<td>2.0</td>
</tr>
<tr>
<td>Coffee grounds</td>
<td>2.1</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>Lawn clippings</td>
<td>1.2</td>
<td>0.3</td>
<td>2.0</td>
</tr>
<tr>
<td>Compost</td>
<td>0.3</td>
<td>0.2</td>
<td>0.4</td>
</tr>
<tr>
<td>Green manure, rye</td>
<td>2.0</td>
<td>0.2</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Inorganic fertilizer

- Sold on a percent by weight basis
  \[N + P_2O_5 + K_2O\]
- Chemically simple
  - N in air plus natural gas
  - rock phosphate, potash mined, sized and cleaned
    - very soluble salts
    - easily blended
    - must be careful with rates

<table>
<thead>
<tr>
<th>Type</th>
<th>N</th>
<th>P2O5</th>
<th>K2O</th>
</tr>
</thead>
<tbody>
<tr>
<td>urea</td>
<td>46</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>ammonium nitrate</td>
<td>33</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>triple super P</td>
<td>0</td>
<td>46</td>
<td>0</td>
</tr>
<tr>
<td>ordinary super P</td>
<td>0</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>muriate of potash</td>
<td>0</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>potassium sulfate</td>
<td>0</td>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>Miracle Gro</td>
<td>15</td>
<td>30</td>
<td>15</td>
</tr>
<tr>
<td>Standard</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

Recommended Fertilization

- Depends on what you are fertilizing
- Why you are fertilizing it
- Soil test report
Soil Pests
- Insects
- Diseases
- Vertebrates

Soil Insects
- Grubs – larvae of Beetles
- Maggots – larvae of Flies
- Cutworms – larvae of butterflies and moths

Soil Insects
- Centipedes, millipedes, sowbugs (pillbugs)
- Ground-dwelling bees

Control

Seriously...
- Crop Rotation
- Cultural practices
  - Cutworm collars
  - Modify moisture
- Pesticides
Soil Diseases
• Biotic Pathogens
  - Fungi
    • Verticillium wilt
    • Fusarium wilt
  - Root rot organisms – Pythium, Rhizoctonia, Phytophthora,
    • Schlerotinia

Soil Diseases
• Biotic Pathogens
  - Bacteria- few soil-borne
    • Nematodes
      • Root knot nematodes

Soil Diseases
• Abiotic Pathogens
  - Black Walnut (Juglans) toxicity

Understanding, respecting and nurturing the soil your plants grow in is the best control strategy for plant pests and problems.

Soil management is the basis of organic gardening.

A nation that destroys its soils, destroys itself.
- President Franklin D. Roosevelt, Feb. 26, 1937.
Good gardening starts at ground level...

...and depends entirely on a six inch layer of soil and the fact that it rains!

(and a little sunshine, of course!)