Composting and Good Soils: A Gardener’s Best Tools
Why should we care about healthy soils?

- Sustain us and make possible our food, shelter, fiber and so much more.
- Promote development of beneficial microbial communities (bacteria/fungi) that allow plants easy access to moisture and nutrients.
- Play an important role in mitigating climate change, through carbon storage and reduction of greenhouse gases.
The Importance of Cycles
Back to the Basics: Elements
(Atoms → Molecules → Everything!)

macronutrients: elements needed in large quantities by your body.

trace elements: elements that are needed in very small quantities to maintain optimum health.
Chemistry is all around (and in) us!

**Water Molecule**

- **H** (Hydrogen) - White
- **O** (Oxygen) - Red
- **H** (Hydrogen) - White

**Glucose**

- **C** (Carbon) - Black
- **O** (Oxygen) - Red
- **H** (Hydrogen) - White

**Ethanol**

- **C** (Carbon) - Black
- **H** (Hydrogen) - White
- **O** (Oxygen) - Red

- **Structural formula**

- **Molecular formula**

- **Chemical formula**: C<sub>2</sub>H<sub>5</sub>OH
Some of the compounds in a leaf
Plants feed themselves *and* the soil

\[ 6\text{ CO}_2 + 6\text{ H}_2\text{ O} \rightarrow \text{ C}_6\text{ H}_{12}\text{ O}_6 + 6\text{ O}_2 \]

- Carbon dioxide from the atmosphere
- Water
- Organic matter
- Oxygen
The Soil Food Web

Figure 3.1 Soil organisms and their role in decomposing residues. Modified from D.L. Dindal, 1978.
How Can Soils Help Fight Climate Change?

First, a few definitions:

- "Global warming" refers to the long-term increase in Earth's average surface temperature.
- "Climate change" refers to any long-term change in Earth's climate, or in the climate of a region or city. This includes warming, cooling and changes besides temperature.
- The “Greenhouse Effect” refers to the natural process that traps heat from solar radiation via a layer of atmospheric gases (such as CO2, CH4 and N2O) that surround the Earth.
The Carbon Cycle: Our role
Atmospheric CO$_2$ Concentrations
Human-Caused CO2 Emissions vs. Atmospheric CO2 Concentrations
How can soils sequester Carbon?

- **Soil Minerals (a little):**
  \[
  \text{CO}_2 + \text{CaO} = \text{CaCO}_3 \\
  \text{CO}_2 + \text{MgO} = \text{MgCO}_3
  \]

- **Plants (a lot):** make and store C; send extra C to soil to feed microbes
Soils 101

- **Soil Formation Factors:** ClORPT: Climate, Organisms, Relief, Parent Material and Time
- **Soil Texture:** Sand/Silt/Clay
- **Soil Structure:** Aggregates protect organic matter. Organic matter builds aggregates.
- **Soil Biology and Chemistry:** Good soil management fosters active and diverse soil biology and chemistry, which increases resilience and moisture/nutrient availability.
Elements of Sustainable Soil Health Management

- Low/no till: minimal disruption
- Organic matter additions (compost, mulch, manures)
- Roots in the Ground
  
  Cover cropping and continuous cover, with a diverse variety of plants
Best Cover Crops for Northeast Vegetable Gardens*

- Spring: Clovers, Buckwheat, Hairy Vetch
- Late Summer: Oats/Peas mixture, Buckwheat

*Note: Rye, though recommended, can be very invasive and hard to control, as well as allelopathic

*www.gardening.cornell.edu/factsheets/ecogardening/impsoil.html
Why Continuous Cover?

*Bare soils are unproductive and unsustainable!*

Cover crops:

- Minimize soil erosion/water runoff
- Minimize nutrient loss
- Keep carbon in the soil
- Reduce compaction/increase aeration
- Suppress weeds
- Attract beneficial insects/pollinators
- “Fix” atmospheric N (legumes)
- Foster mycorrhizal fungi
- Add soil organic matter
Legumes “fix” N
Arbuscular Mycorrhizal Fungi

- A symbiosis between fungus and root (+80% of all plants have it). Nutrient/H₂O superhighway
- AMF hyphae produces glomalin, a glycoprotein that helps create stable soil aggregates (structure)
Adding Organic Matter: Benefits of Backyard Composting

- Waste Reduction
- Greenhouse Gas Reduction (CO$_2$, CH$_4$)
- Organic Matter “Creation”
Waste Reduction

U.S. Household Trash Generation:

3/4 ton per person per year (4.3 lbs./day)

- 25% is food/yard waste (45 m tons)
- 40% of all food produced is discarded
Greenhouse Gas (GHG) Reduction

- Composting reduces methane (CH$_4$) from landfills by facilitating aerobic decomposition.

- Removing organic waste from incinerators makes the process less polluting.

- Utilizing compost keeps carbon in the soil, reducing formation of CO$_2$ and feeding soil microorganisms.
Five Essentials of Composting

Carbon:Nitrogen (C:N) Ratio
Volume
Moisture
Aeration
Surface Area
Carbon:Nitrogen (C:N) Ratio

- Materials High in Carbon: (2 parts)
  
  “Browns”: Dry, brown materials such as leaves, straw, paper, woodchips, sawdust

- Materials High in Nitrogen: (1 part)
  
  “Greens”: Moist, fresh materials such as vegetative food scraps and garden waste

Always cover greens with browns!
### Average Carbon-to-Nitrogen (C:N) Ratios for Organic Materials

<table>
<thead>
<tr>
<th>GREENS/ NITROGEN</th>
<th>C:N RATIO</th>
<th>BROWNS/ CARBON</th>
<th>C:N RATIO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pig manure</td>
<td>5-7:1</td>
<td>Leaves</td>
<td>30-80:1</td>
</tr>
<tr>
<td>Poultry manure (fresh)</td>
<td>10:1</td>
<td>Cornstalks</td>
<td>60:1</td>
</tr>
<tr>
<td>Alfalfa or sweet clover hay</td>
<td>12:1</td>
<td>Straw</td>
<td>40-100:1</td>
</tr>
<tr>
<td>Vegetable scraps</td>
<td>12-20:1</td>
<td>Bark</td>
<td>100-130:1</td>
</tr>
<tr>
<td>Poultry manure with litter</td>
<td>13-18:1</td>
<td>Paper</td>
<td>150-200:1</td>
</tr>
<tr>
<td>Coffee grounds</td>
<td>20:1</td>
<td>Sawdust</td>
<td>400:1</td>
</tr>
<tr>
<td>Grass clippings</td>
<td>12-25:1</td>
<td>Wood chips</td>
<td>800:1</td>
</tr>
<tr>
<td>Cow manure</td>
<td>20:1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horse manure</td>
<td>25:1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horse manure with litter</td>
<td>30-60:1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**SOURCE:** Clemson Extension Master Gardener Program
Composting High Carbon Materials Only
(compensate for low N by adding moisture)
2. Volume
3. Moisture
4. Aeration
5. Surface Area
What can you Compost?

Yes!

No!
Composting Methods: Hot (batching) vs. Cool
Composting Systems (cont’d)
Regardless of system, leave room to turn the pile.
Composting Tools:

- Compost Fork*
- Spade*
- Thermometer
- Turning tool
- Accelerators

*only essential tools
Composting Kitchen Scraps Separately
Soil Incorporation
Worm Composting
(Vermicomposting)
Using Finished Compost
(A soil amendment, not a fertilizer)
Using Finished Compost: Plant Nutrient Overview

macronutrients: elements needed in large quantities by your body.

trace elements: elements that are needed in very small quantities to maintain optimum health.
Benefits of Using Finished Compost

- Improves soil health, “tilth”, structure, making life better for plants and soil organisms
- Conserves moisture (enabling nutrient uptake) and moderates soil temperature, reducing plant stress
- Organic matter fuels microbial activity, making minerals available to plants and reducing the need for chemical inputs and reducing NPS pollution
- Suppresses pathogens, reducing plant diseases
- Neutralizes soil pH, which increases nutrient availability
- Increases Cation Exchange Capacity (CEC)
- Etc., etc., etc.
Using Finished Compost: pH and Nutrient Availability

How soil pH affects availability of plant nutrients

<table>
<thead>
<tr>
<th>High</th>
<th>Medium</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Acid</td>
<td>Medium Acid</td>
<td>Slightly Acid</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>Phosphorus</td>
<td>Potassium</td>
</tr>
<tr>
<td>Slightly Alkaline</td>
<td>Medium Alkaline</td>
<td>Strongly Alkaline</td>
</tr>
</tbody>
</table>

Optimum soil pH range: 6.2 - 7.3
Using Finished Compost

- Top or Side Dress
- Potting Mix
- Soil Incorporation (herbaceous plants only)
- Seed Starting Mix (mature compost)
- Compost Tea
Invest in a Soil Test

Soil Test Report

Sample ID: Veggie Garden

Results and Interpretations

pH: 6.50 Slightly acidic; optimum pH range of many plants except acid-loving species.

Lime Requirement Index: 7.90
The Lime Requirement Index (LRI) is a measure of the buffering capacity of the soil, its resistance to pH change, and is used to determine the appropriate amount of limestone, when necessary. LRI value near 8.0 indicates low buffering capacity of soil and a lower rate of limestone amendment compared to soil with high buffering capacity (LRI near 7.0).

Macronutrients (pounds per acre)

- Phosphorous: 672 (Above Optimum)
- Potassium: 2010 (Above Optimum)
- Magnesium: 749 (Above Optimum)
- Calcium: 4051 (Above Optimum)

by Mehlich 3 extraction

Micronutrients (parts per million)

- Zinc(Zn): 22.46 (Adequate)
- Copper(Cu): 3.16 (Adequate)
- Manganese(Mn): 73.82 (High)
- Boron(B): 2.46 (Adequate)
- Iron(Fe): 330.70 (High)

Special Tests Results
No special test data available