Plant/Soil and Environmental Benefits of Compost Use

By: Ron Alexander

Principal, R. Alexander Associates, Inc. **6/18/09**

Current Issues – Compost Impacts

- **Societal Sustainability**

  - Water quality and management/stormwater
  - Soil quality - biofiltration ability, plant growth, food production

  - Climate change (CO_2)

Current Issues – Compost Impacts

- **Societal Sustainability**
  - **Reduction of chemical inputs**
  - **Land reclamation / brownfields**
  - **Toxins to environment and humans**

Current Status

- **Create "products"**
  - **Unique, many composts are better and more economical to use**
  - **Valuable and sustainable benefits**
  - **Replacement for virgin and less 'green' products**

Sept. 4, 2007

SARASOTA COUNTY, Fla. -- **Taking one of the boldest moves of any metropolitan area in the United States, officials in Sarasota County in Florida voted this week to ban business owners and residents from using chemical fertilizers** during the rainy season.

Citing water quality and red tide concerns that have been associated with the overuse of chemical fertilizers -- especially on lawns -- the County will also institute "fertilizer free zones" within ten feet of bodies of water and sharply limit the amount of nitrogen and phosphorus than can be applied at any time of year.

The move was hailed by environmental groups across the nation, who believe the action in Florida will spur other communities across the nation to enact similar legislation. In Florida alone, **Charlotte and Manatee counties are considering following Sarasota's lead, as are the city of Jacksonville and Hillsborough County.**

"We think it is significant that **Sarasota County has joined other coastal counties such as those in Maryland, Massachusetts and New York** to protect the vital estuaries in their bounds, said **Shepherd Ogden, Executive Director of SafeLawns.Org**. "Their leadership will show the way nationwide for more efficient and environmentally sensitive approaches to lawn and landscape care."

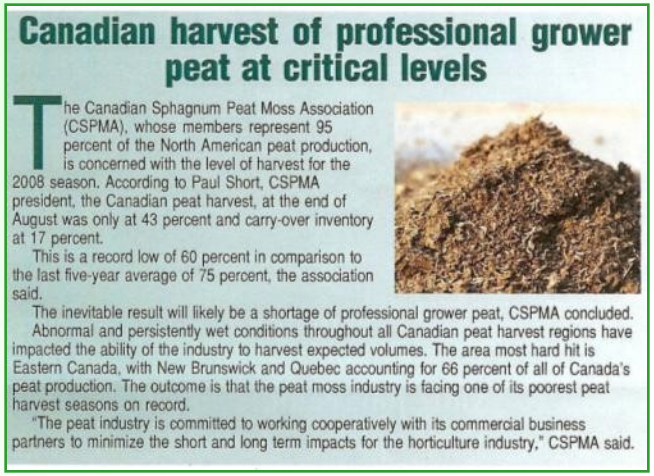
Sarasota County, with nearly 400,000 residents, approved its rules after more than a year of hearings that included homeowners, business leaders and scientists, along with lobbyists for the fertilizer and pest control industry, some of whom strongly opposed the County action. It bans the use of chemical fertilizers from June 1 to Sept. 30 beginning in February 2008. In addition to limiting the amounts of phosphorus and nitrogen that can be applied per year, **the ordinance recommends the use of fertilizers which contain at least 50 percent slow-release nitrogen** -- which includes all organic fertilizers, which are slow-release by nature.

Companies and residents in violation of the fertilizer rules will face penalties that start with a warning notice and increase to a $500 fine for a third offense. Everyone involved realizes that enforcement will be an issue, but that misses the point, according to County leaders.

"I think the real significance of the ordinance is to get people to realize there is a cause and effect with the way fertilizers and pesticides are applied and how it affects our environment," County Commissioner Paul Mercier said.

Resigned to changes in the laws, some within the chemical fertilizer industry see an opportunity. **Mary Hartney, president of the Florida Fertilizer and Agrichemical Association**, suggested the fees for violating the ordinance could be used to create a public education program about fertilizer. Both sides of the issue see passage of the ordinance as only the beginning.

"There's too much at stake here," said **County Commissioner Joe Barbetta**. "The watercourses are challenged every day and we've got to do something to stop it."



Canadian harvest of professional grower peat at critical levels

The Canadian Sphagnum Peat Moss Association (CSPMA), whose members represent 95 percent of the North American peat production, is concerned with the level of harvest for the 2008 season. According to Paul Short, CSPMA president, the Canadian peat harvest, at the end of August was only at 43 percent and carry-over inventory at 17 percent.

This is a record low of 60 percent in comparison to the last five-year average of 75 percent, the association said.

The inevitable result will likely be a shortage of professional grower peat, CSPMA concluded.

Abnormal and persistently wet conditions throughout all Canadian peat harvest regions have impacted the ability of the industry to harvest expected volumes. The area most hard hit is Eastern Canada, with New Brunswick and Quebec accounting for 66 percent of all of Canada's peat production. The outcome is that the peat moss industry is facing one of its poorest peat harvest seasons on record.

"The peat industry is committed to working cooperatively with its commercial business partners to minimize the short and long term impacts for the horticulture industry," CSPMA said.

R. Alexander Associates, Inc.

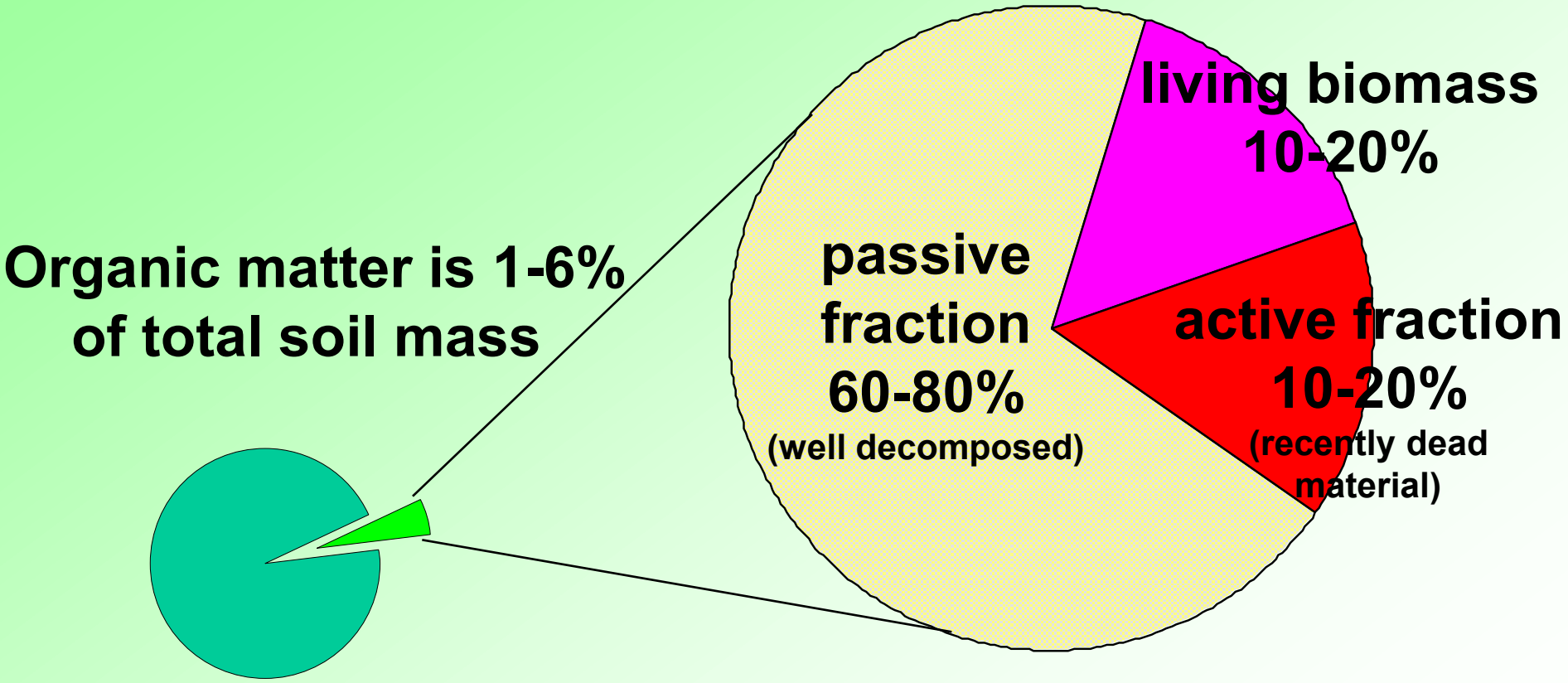
Compost / Composting

Various types of composts in California

- 100 Commercial Licensed

- 3 million CY of compost

Soil Organic Matter



-Think about the carbon cycle
-All organic matter is not the same

The previous slide shows two pie charts to illustrate Soil Organic Matter

- Small pie chart: organic matter is 1-6% of total soil mass
  - This pie shows a small slice to represent the organic matter and points to the larger pie chart.
- Larger pie chart: shows soil organic matter breakdown:
  - 60-80% - passive fraction (well decomposed)
  - 10-20% - active fraction (recently dead material)
  - 10-20% - living biomass

Summary:

- Think about the carbon cycle
- All organic matter is not the same

Comparing Active and Passive OM

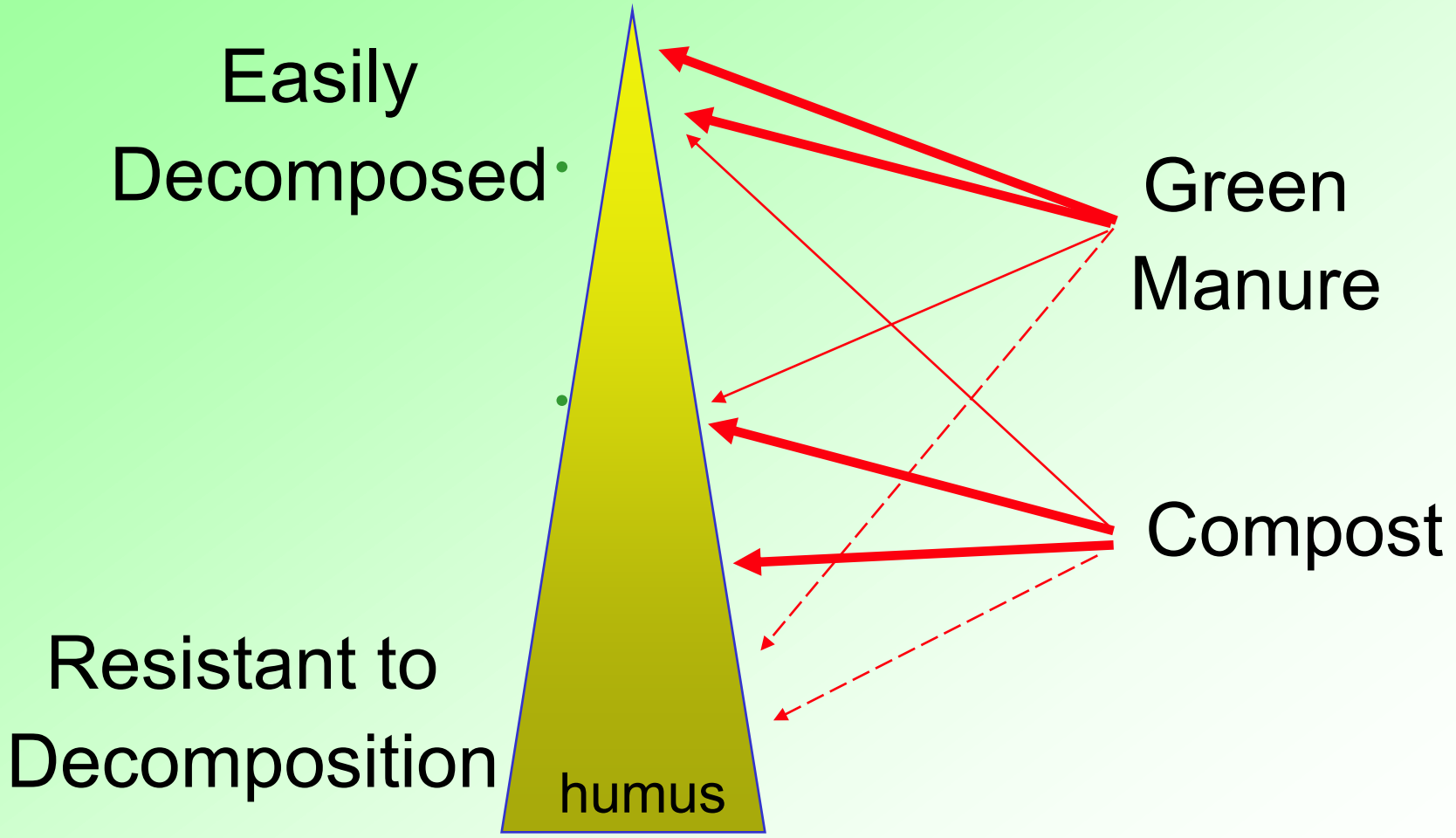
Active	Passive
Rapid turnover smaller % of OM causes ***INDIRECT*** effects	Slow turnover larger % of OM causes ***DIRECT*** effects
Newer OM	*Older OM*

Role of Soil Organic Matter

Two Major Components:

- **Direct effects** of the organic matter itself
  - –soil structure, chelation of micronutrients, pH buffering capacity
- **Indirect effects** of decomposition of organic residues
  - –aggregation, nutrient release, biological activity, disease suppression

Soil Organic Matter Continuum

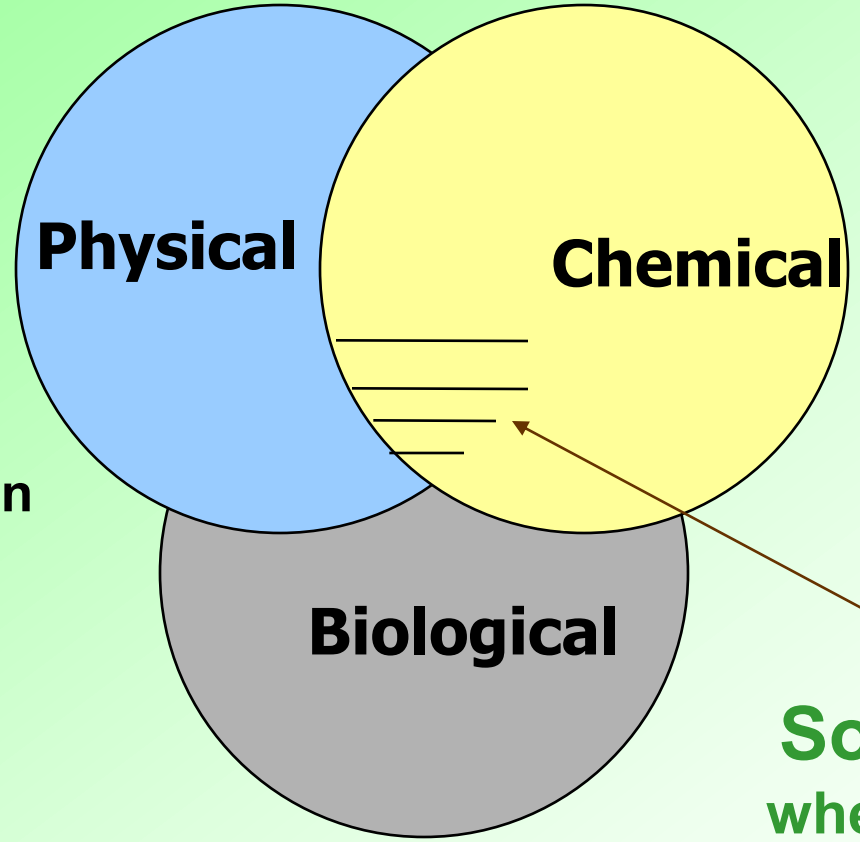


The previous slide shows a scale of the Soil Organic Matter Continuum

- The scale illustrates that some compostable items are easier to decompose that others.
- From easiest to decompose to those resistant to decomposition are:
  - Green manure
  - Compost
  - Humus

Soil Health

- Root proliferation
- Aeration
- Water retention
- Water infiltration and transmission
- Erosion prevention



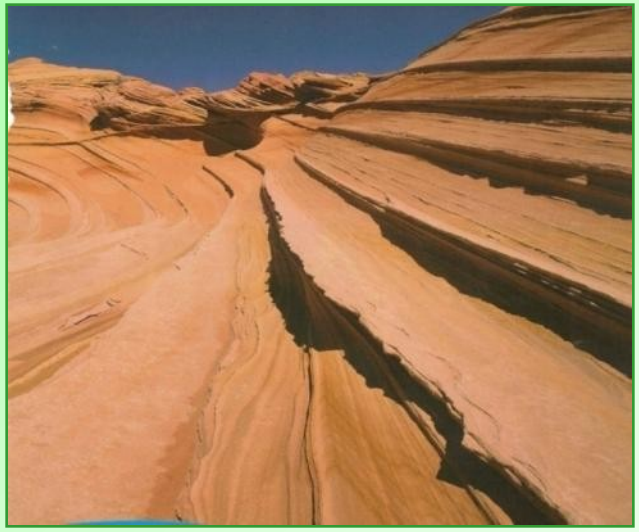
- Nutrient retention and release
- pH
- Energy (C) storage
- Toxicity prevention

- Pest suppression
- N mineralization
- OM decomposition
- Habitat protection

Soil Health:
where physical, chemical and biological health intersect

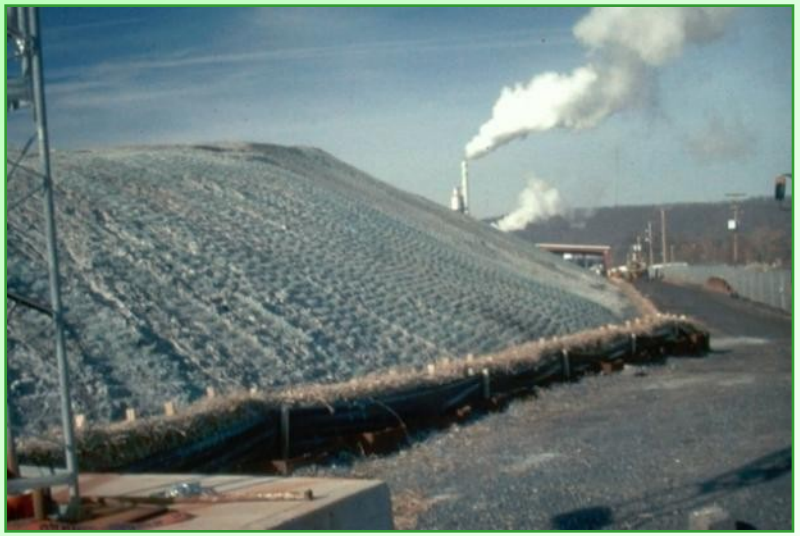
Aside from landscape uses, we have bigger issues to tackle

Soil Conservation / Protection

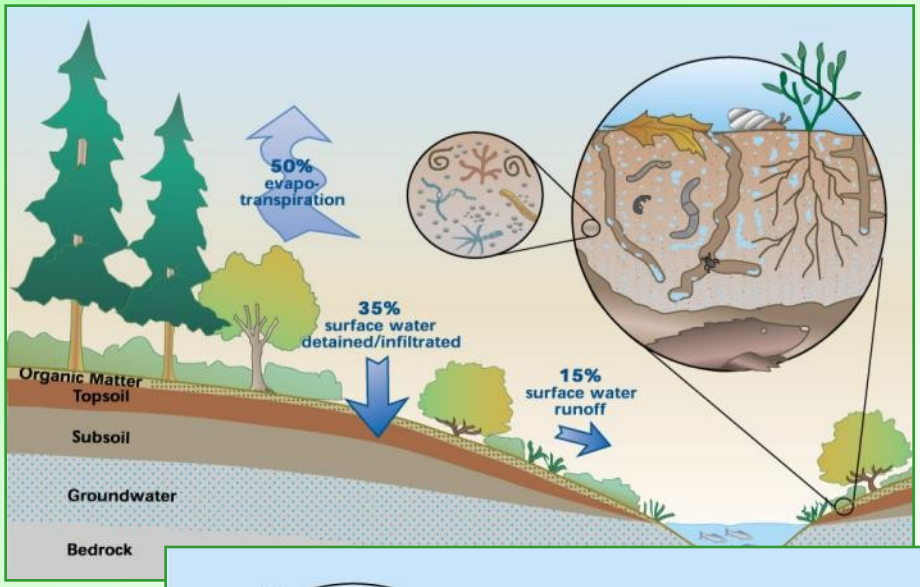


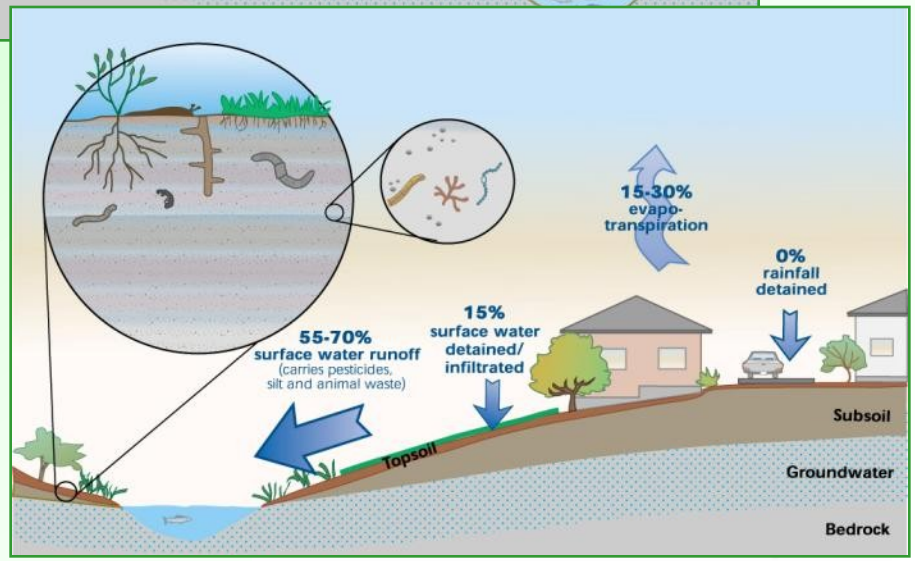
USA – 5B tons topsoil lost through erosion
- Swain 1992

Reclamation, Brownfields, Remediation



Surface Water Protection

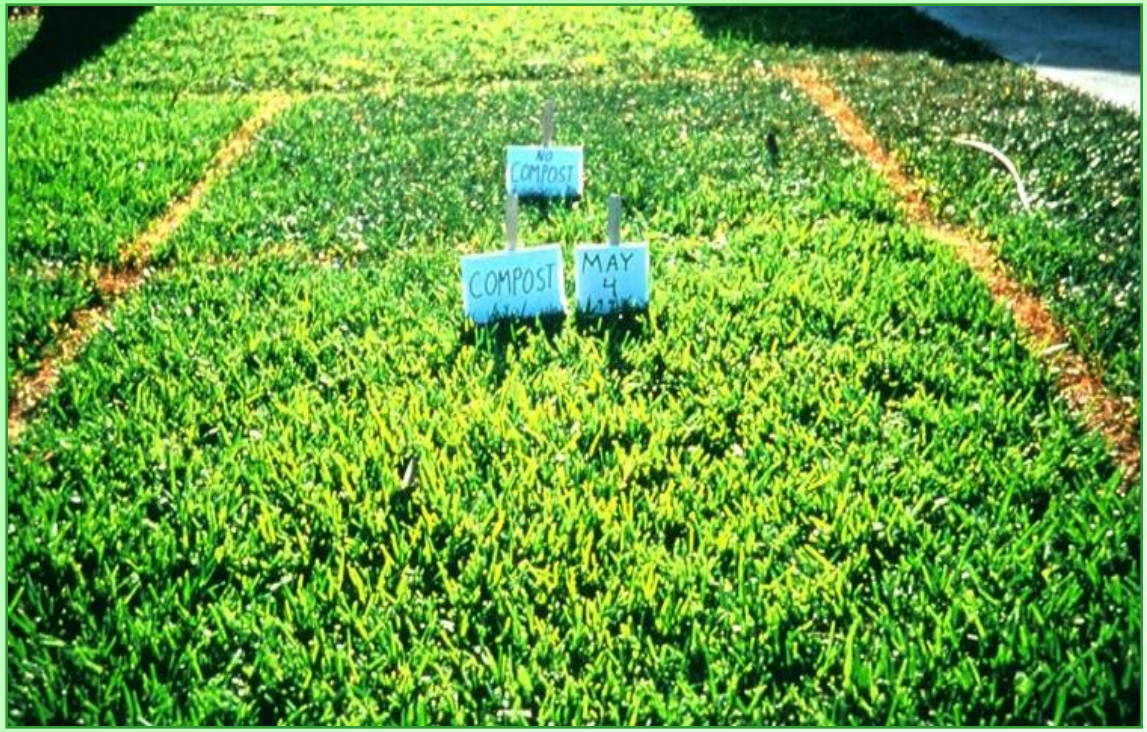




Salmon spawning waters degraded

Source: www.SoilsforSalmon.org

Water Conservation



Flood and Stormwater Mgt

Compost in bioengineering

Need to manage more, find less expensive methods

50 / 100 year storms?

Flood and Stormwater Mgt

Enhanced Food Production / Declining Agricultural Soil Quality

On a global scale the annual loss of 75 billion tons of soil

- NRCS, 2003 data

• Nearly 40 percent of the world's agricultural land is seriously degraded due to problems like erosion and nutrient depletion, raising doubts about its ability to produce food in the future

• Degradation has already significantly lowered the productivity of 16 percent of farmland worldwide

International Food Policy Research Institute

• Food shortages in 2008 caused riots in Asia, Africa and Latin America

• In 2030, expect a world population of 8.3 billion people, requiring 30% more grain production

• 2008 had the highest fertilizer prices in history

Water Conservation

- S. Cal can cost $800/A/ft. H_2O for farmers
- Univ. of IL – 12/04 – adding 1 A inch of H_2O / acre is $160 - $347 in energy alone

"When the well's dry, we know the worth of water."
B. Franklin, *Poor Richard's Almanac*

Sprinkler Installation Fees Grow in TX

Some new requirements include placing sprinkler heads no closer than four inches from a sidewalk or street to prevent overspray, adding valves to shut off the water flow in case of line breaks and installing automatic controllers with water conservation features.

New state and local laws in Texas will require in-ground sprinkler systems installed in 2009 to be more efficient at conserving water –which will impact costs for installers.

Cities with populations over 20,000 have recently adopted or are working to adopt new ordinances that reflect state requirements for the installation of commercial and residential irrigation systems. Starting January 1, irrigation systems will need permits and inspections as well as a checklist of rules designed to better regulate outdoor water usage to reduce runoff and evaporation. All sprinkler design plans must now be reviewed and approved by the city.

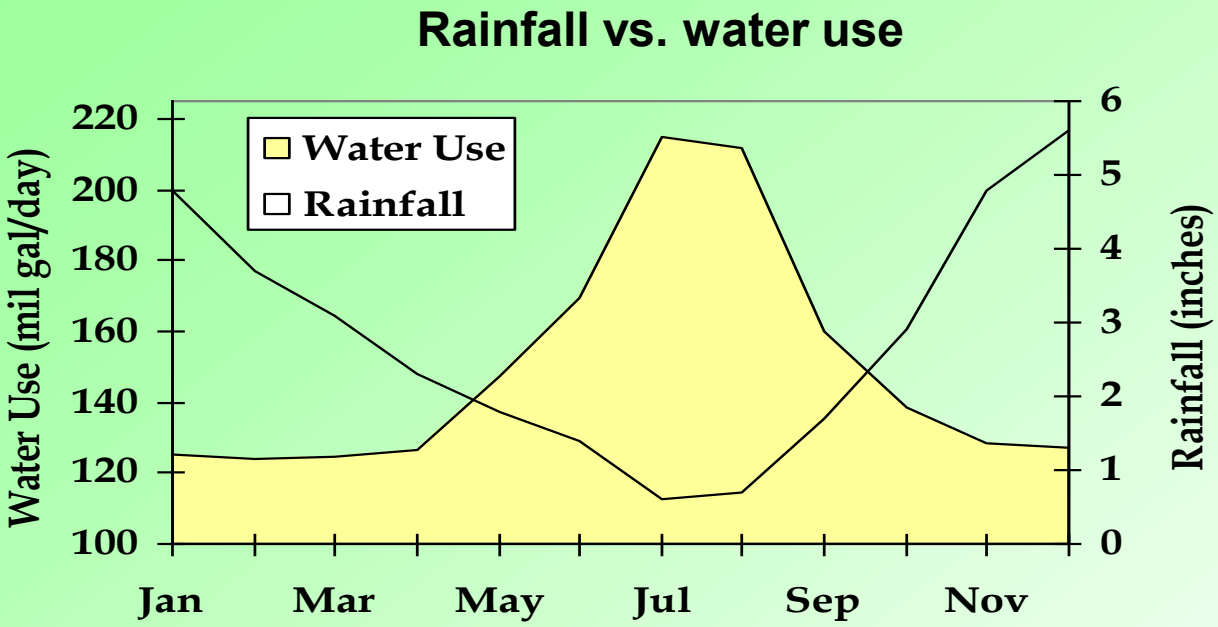
Dallas' irrigation ordinance, which includes some rules that are stricter than the state regulations, will go before the City Council in December. Arlington's irrigation ordinance is being considered and Fort Worth's ordinance is still being drafted, city officials said.

Outdoor watering accounts for about 50 percent of public drinking water usage during the summer, city officials said. Last July, the city of Arlington treated an average of 97 million gallons of water a day to keep up with demand — 51 million more gallons per day than it treated in January, said Dustan Compton, Arlington's conservation program coordinator.

And up to 50 percent of water for irrigation is wasted due to over-watering, watering during the rain or heat of the day, or watering of impervious surfaces, officials said.

Source: Susan Schrock, www.star-telegram.com

Water Conservation



Summer landscape irrigation use

Need to reduce overall and peak usage, but more sprinkler's are coming

The previous slide shows a graph presenting water use vs. rainfall

The x axis presents months: January thru December

The left y-axis presents water use from 100 to 220 million gal/day

The right y-axis presents rainfall from 0 to 6 inches

- Water use line starts ~ 125 ml/gal/day and peaks in July at ~ 210 then tapers off in Oct/Nov back to 125 ml/gal/day
- The rainfall line starts at ~ 5 in. and then drops in July to < 1 in. and then gradually increases to 5.5 in. in Oct/Nov.
- In other words, when water use is at its highest, rainfall is at the lowest.

Influence of Compost on Soil Water Management

Western Washington Loamy Sand (% dairy solids compost added)	**OM (%)**	**Saturated Hydraulic Conductivity (in/hr)**	**Moisture at Field Capacity (weight %)**	**Moisture at Field Capacity (in/ft)**	**Bulk Density (g/cm^3)**
0	2.0	4.3	21.5	2.2	1.20
10	2.0	4.3	26.8	2.7	1.28
20	2.4	5.4	37.0	3.7	1.09
30	4.4	7.5	50.9	5.1	0.99

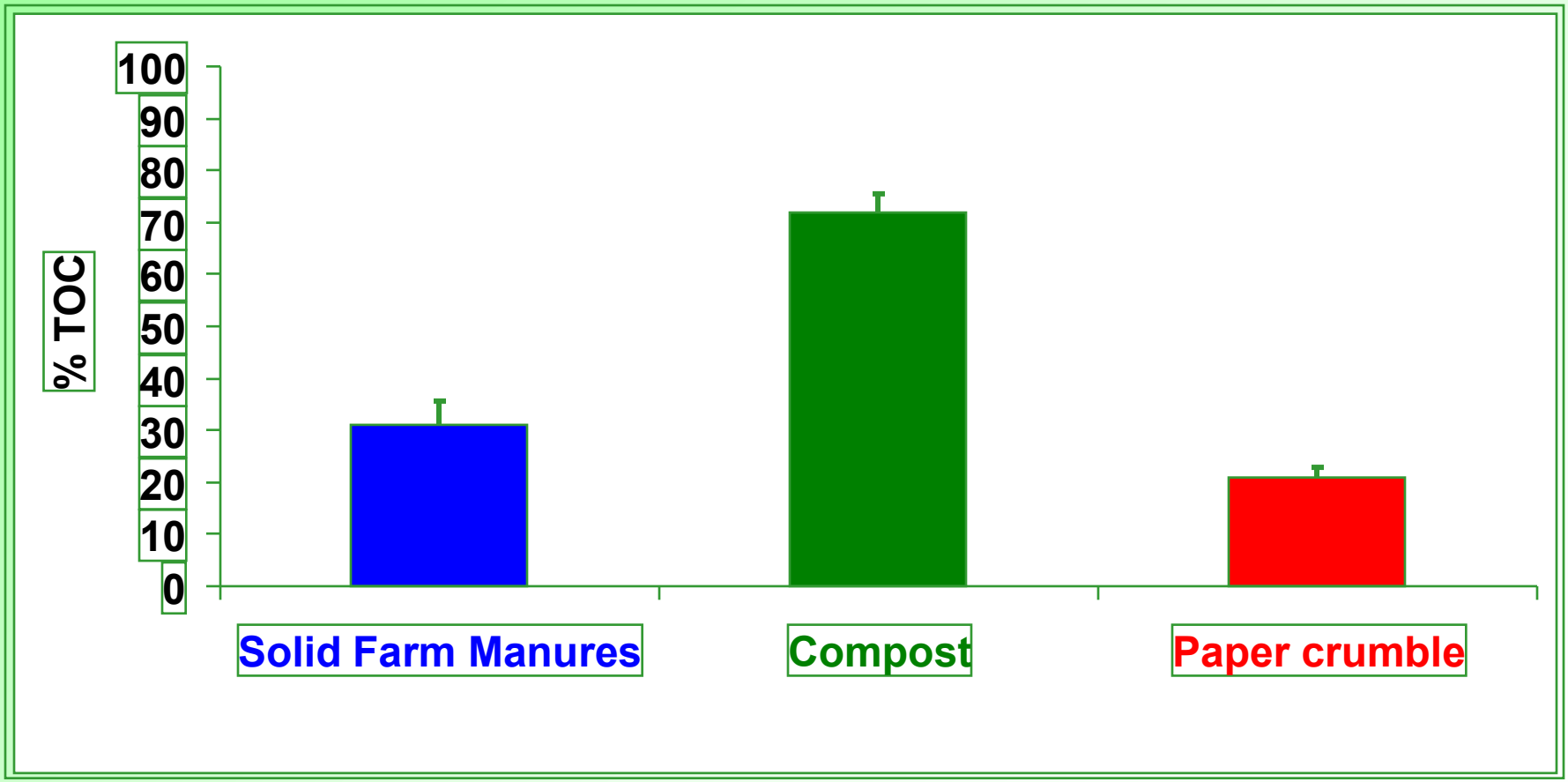
Great tool for water management – too much, too little

WORC/ECY 2008

Climate Change

- **Composting or AD, instead of landfilling**
  - Reduced methane generation
  - 2005 - 25M tons of food waste to landfill, if composted would offset CO_2 from 7.8 M passenger cars
  - If captured and used energy – green energy could further offset fossil fuel production
- **Compost use instead of petroleum based fertilizer or pesticides**
- **Compost as a carbon dioxide sink (sequestration)**
  - Kyoto Protocol allows for CO_2 sink as a carbon offset
  - ATTRA – 1% increase of organic carbon in soil can sequester 132 tons/hectare of CO_2

Long Lasting Organic Matter
– Lignin as % of Total Organic Carbon



The previous slide shows a histogram of the Long Lasting Organic Matter – Lignin as Percent of Total Organic Carbon

The x axis shows three bars: solid farm manures, compost, and paper crumbles.

The y axis shows percent of Total Organic Carbon (TOC) from 0 to 100%.

- Compost has the highest percent of TOC ~ 70 %
- Manures ~ 30 %
- Paper ~ 20 %

Benefits of Compost Use to the Landscape World

Physical:

- Improves soil structure
- Moisture management

Chemical:

- Modifies and stabilizes pH
- Increases cation exchange capacity
- Supplies nutrients

Biological:

- Supplies soil biota
- Suppresses plant diseases

Other:

- Binds/degrades contaminants
- Binds nutrients

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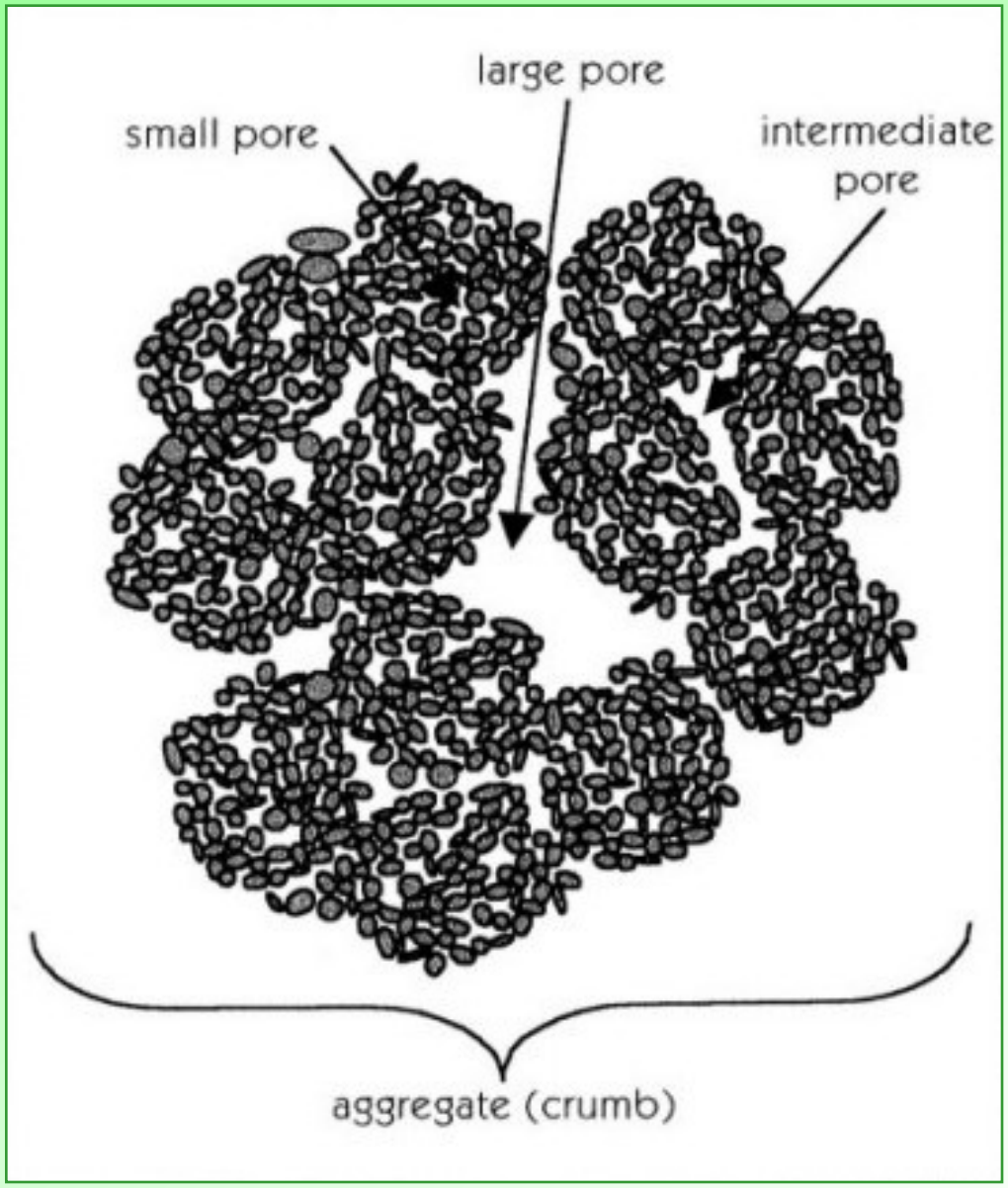
Soil Structure: Physical Modification

Oxygen,
water,
nutrient,
pesticide
movement,

pore space

Soil Aggregation

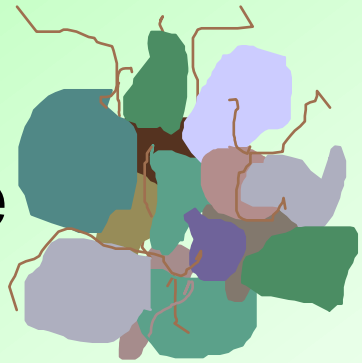


A well aggregated soil has a range of pore sizes.This medium size soil crumb is made up of many smaller ones. Very large pores occur between the medium size aggregates.

Less wind and water erosion, better accepts water

Soil Structure:
Biological mechanisms of aggregation

- Fungal hyphae

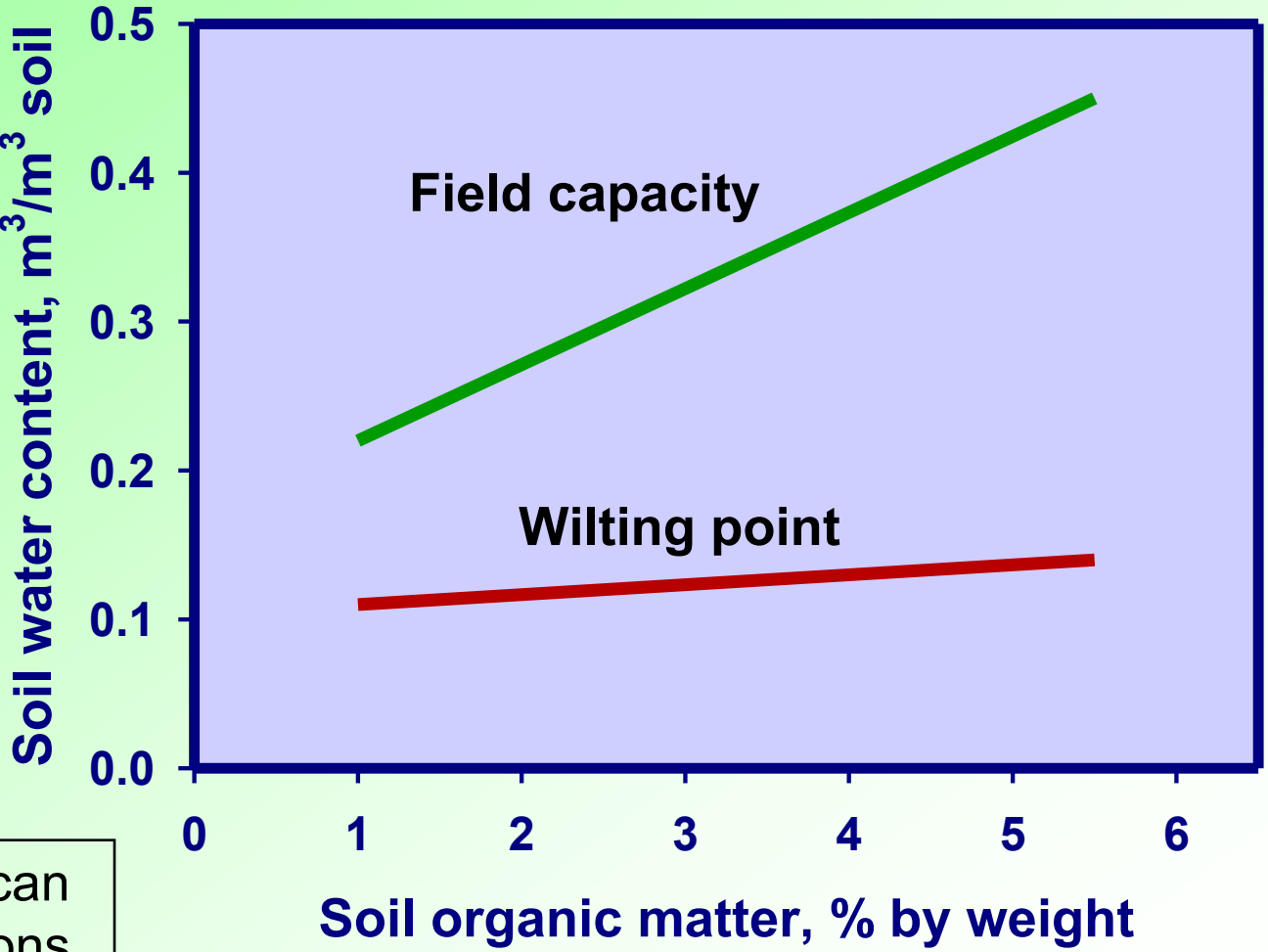


- Gels produced by microbes and plant roots

Improved

- Tilth
- Reduced bulk density
- Improved rooting
- Fuel savings

Effect of Organic Matter on Available Soil Water



- ATTRA – 1% OM can provide 16,500 gallons H_2O/hectare of WHC

The previous slide shows the Effect of Organic Matter on Available Soil Water

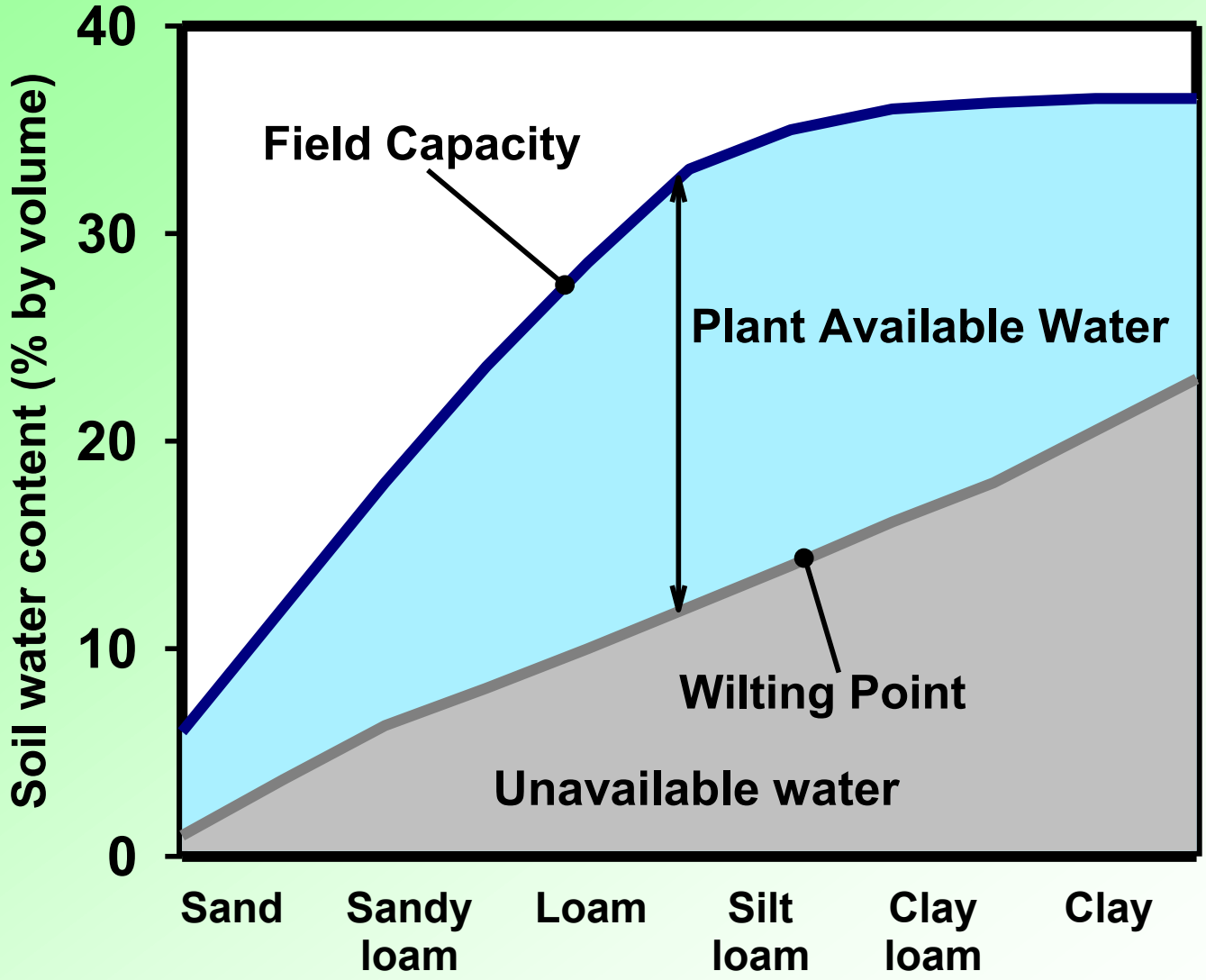
The x axis presents soil organic matter: 0 to 6 percent by weight.

The y axis presents the soil water content: cubic meter/cubic meter (m^3/m^3) of soil – 0.0 to 0.5 m^3/m^3.

There are two lines:

- The bottom line is the "wilting point." It starts at ~ 0.1 and gradually increases to 0.125 m^3/m^3 at 5.5 % by weight soil organic matter.
- The top line is the "field capacity." It starts at ~ 0.2 and increases quickly to 0.45 m^3/m^3 at 5.5 % by weight soil organic matter.

Plant Available Water



Increase the pool of plant available water too

The previous slide shows a graphic illustration of soil's available plant water

This graph provides similar information to the previous graph but instead the x axis presents the soil types: sand, sandy loam, loam, silt loam, clay loam and clay and the y axis presents the soil water content in percent by volume, scale 0 - 40 %.

There are two lines:

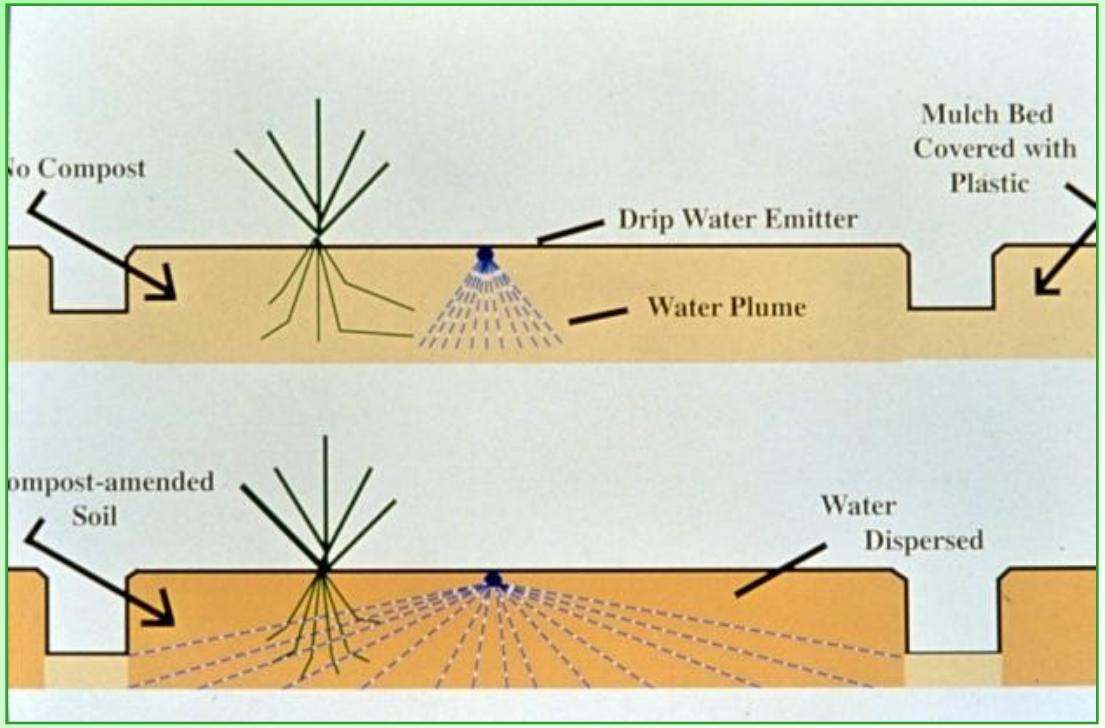
- The bottom line is the "wilting point." It starts at 0 and increases steadily to 20 % at clay.
- The top line is the "field capacity." It starts at ~ 5 % and increases quickly to ~ 35 % at loam then levels off at ~ 38 % from silt loam through clay.

The area in between the two lines is called the "plant available water."

Water Conservation

Improved lateral movement of water – improved efficiency

Huge in CA



Comparison of 2 soil planting beds:

1) The top bed has no added compost - the drip irrigation is not effective as the water does not disperse well and misses the plant root zone.

2) The bottom bed has soil amended with compost - the drip irrigation disperses over a wider area including the plant root zone.

Benefits of Compost Use

Physical:

- Improves soil structure
- Moisture management

Chemical:

- Modifies and stabilizes pH
- Increases cation exchange capacity
- Supplies nutrients

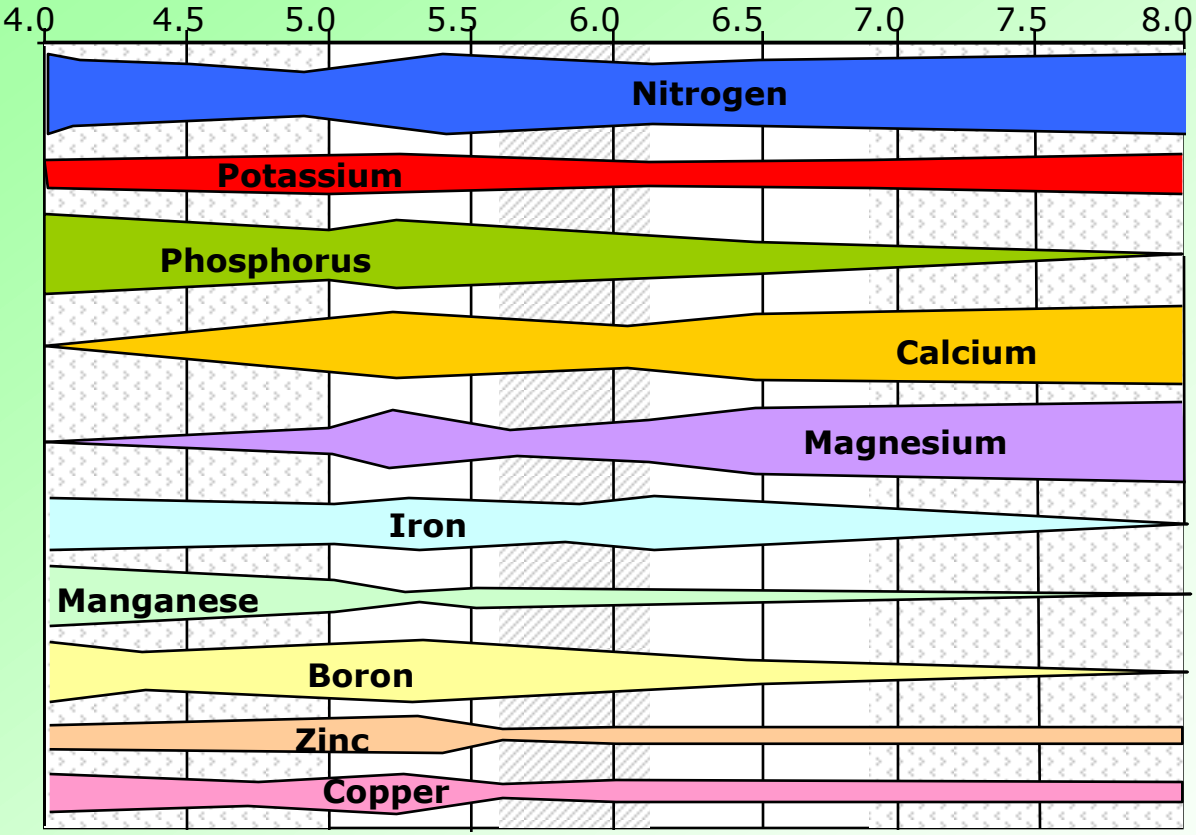
Biological:

- Supplies soil biota
- Suppresses plant diseases

Other:

- Binds/degrades contaminants
- Binds nutrients

Improves Nutrient Availability



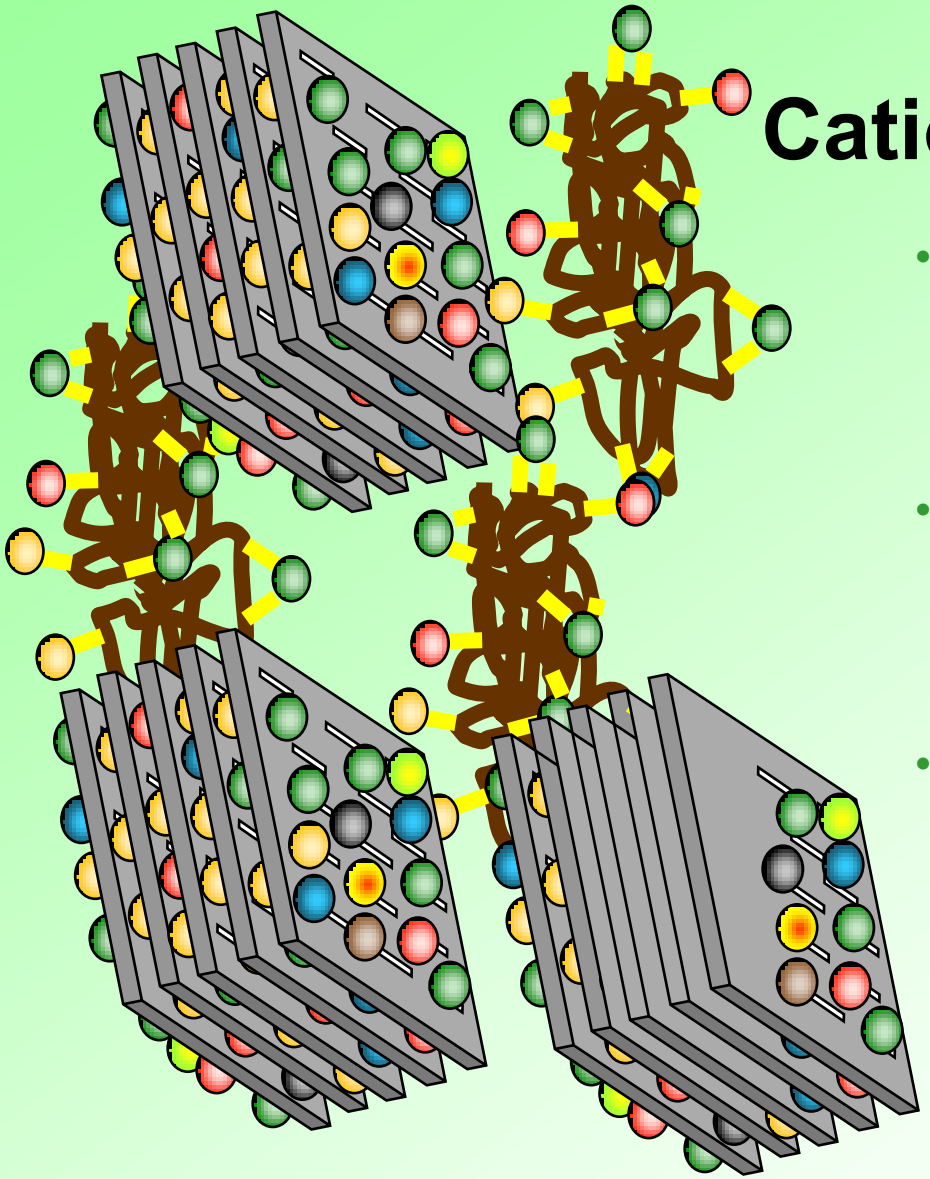
pH and nutrient availability

pH scale is logarithmic

The previous slide is a graphic illustration of how pH Affects Nutrient Availability

- Nutrient absorption is improved with a lower pH (less than 6) for Phosphorus, Manganese, Zinc and Copper, and Boron and for Iron (less than 7)
- Nutrient absorption is improved with a neutral pH (6.5 - 8) for Calcium and Magnesium
- Nutrient absorption stays relatively the same for Nitrogen, Potassium, and Iron across the range of pH from 4 to 8

SOM is a Nutrient Reservoir:



Cation exchange capacity

- Cation exchange capacity (CEC) is the total amount of cations that a soil can retain
- The higher the soil CEC the greater ability it has to store plant nutrients (reservoir)
- Soil CEC increases as
  - The amount of clay increases
  - The amount of organic matter increases
  - The soil pH increases

Nutrient Value

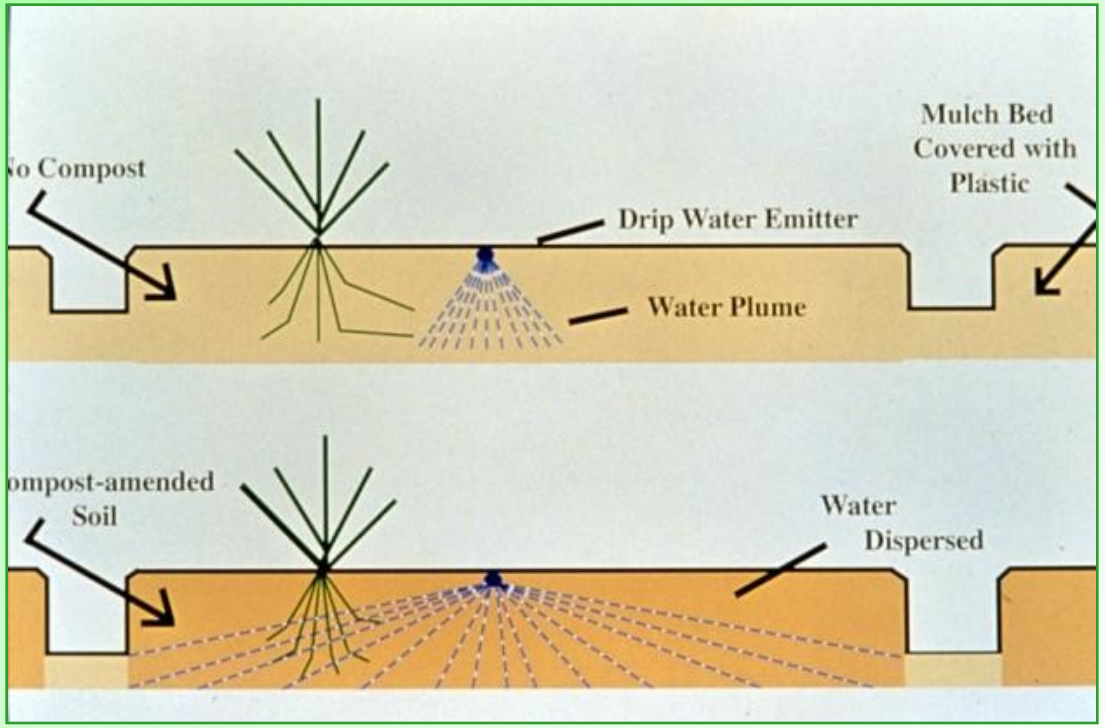
Nutrient*	Value/LB	0.5:0.5:0.5 NPK in Ton of Compost	1-1-1 NPK in Ton of Compost
Nitrogen	$0.92	$4.60	$9.20
Phosphate	$1.22	$6.10	$12.20
Potassium	$0.67	$3.35	$6.70
Total		$14.05	$28.10

-Nutrient sources - Urea (46%N), MAP (52%P) and Muriate of Potash (60%K)
-Values based on a wet ton of compost at 50% moisture content--
-Pricing – summer 2008

Water Conservation

Improved lateral movement of water – improved efficiency

Huge in CA



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Micro / secondary nutrients too

Chart shows nutrients, percent of foliage, and deficiency symptoms

Nutrients and their Concentration in Tree Foliage

Element *(Symbol)*	% of Foliage	Deficiency Symptoms
Nitrogen (N)	1.5	Pale young leaves; chlorosis (yellowing) and premature abscission of older leaves; small, reddish twigs.
Phosphorus (P)	0.2	Small, dark leaves with purple veins; severe stunting.
Potassium (K)	1.0	Interveinal chlorosis of older leaves; scorch and marginal necrosis (browning and death).
Calcium (Ca)	0.5	Chlorosis and scorch of young leaves; tip and terminal bud dieback; stunted roots.
Magnesium (Mg)	0.2	Marginal chlorosis of older leaves; interveinal necrosis at leaf center; undersized fruit.
Sulfur (S)	0.1	Overall uniform chlorosis and stunting of young leaves.
Iron (Fe)	0.01	Sharply defined interveinal chlorosis of young leaves; branch dieback.
Chlorine (Cl)	0.01	General reduction in tree growth.
Manganese (Mn)	0.01	Marginal interveinal chlorosis of older leaves; interveinal necrosis.
Zinc (Zn)	trace	Mottled and striped chlorosis of older leaves; leaves form dwarfed rosettes.
Boron (B)	trace	Terminal shoot dieback; sparse foliage on new lateral shoots; brittle, red-veined, distorted leaves.
Copper (Cu)	trace	Veinal chlorosis; terminal leaves form rosettes, terminal growth dieback;
Molybdenum (Mo)	trace	Marginal chlorosis of old and young leaves followed by interveinal chlorosis; leaf cupping.
Cobalt (Co)	trace	Leguminous trees will not develop nitrogen-fixing bacterial nodules.

Note: These symptoms may vary according to the species, the season and the severity of the deficiency. Reduction in growth may precede the appearance of deficiency symptoms.

Carbon sequestration

- Is the long-term storage of carbon in oceans, soils, vegetation (especially forests), and geologic formations.
- Soil carbon sequestration is the process of transferring carbon dioxide from the atmosphere into the soil crop residues or other organic solids, and in a form that is not immediately remitted.
- Helps offset emissions from fossil fuel combustion and other carbon-emitting activities, while enhancing soil quality and long-term agronomic productivity.
- Soil compost sequestration can be accomplished by management systems that add high amounts of biomass to the soil, cause minimal soil disturbance, conserve soil and water, improve soil structure, and enhance soil fauna activity.

Carbon sequestration

- Soil contains 75% of the carbon pool on land (25% stored in living plants and animals)
- Benefits of soil carbon sequestration
  - Removing CO_2 from the atmosphere
  - Improved soil and water quality
  - Decreased nutrient loss
  - Reduced soil erosion
  - Increased water conservation
  - Greater crop production

Benefits of Compost Use

Physical:

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Chemical:

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Soil Biology

Soil Organisms are Responsible for

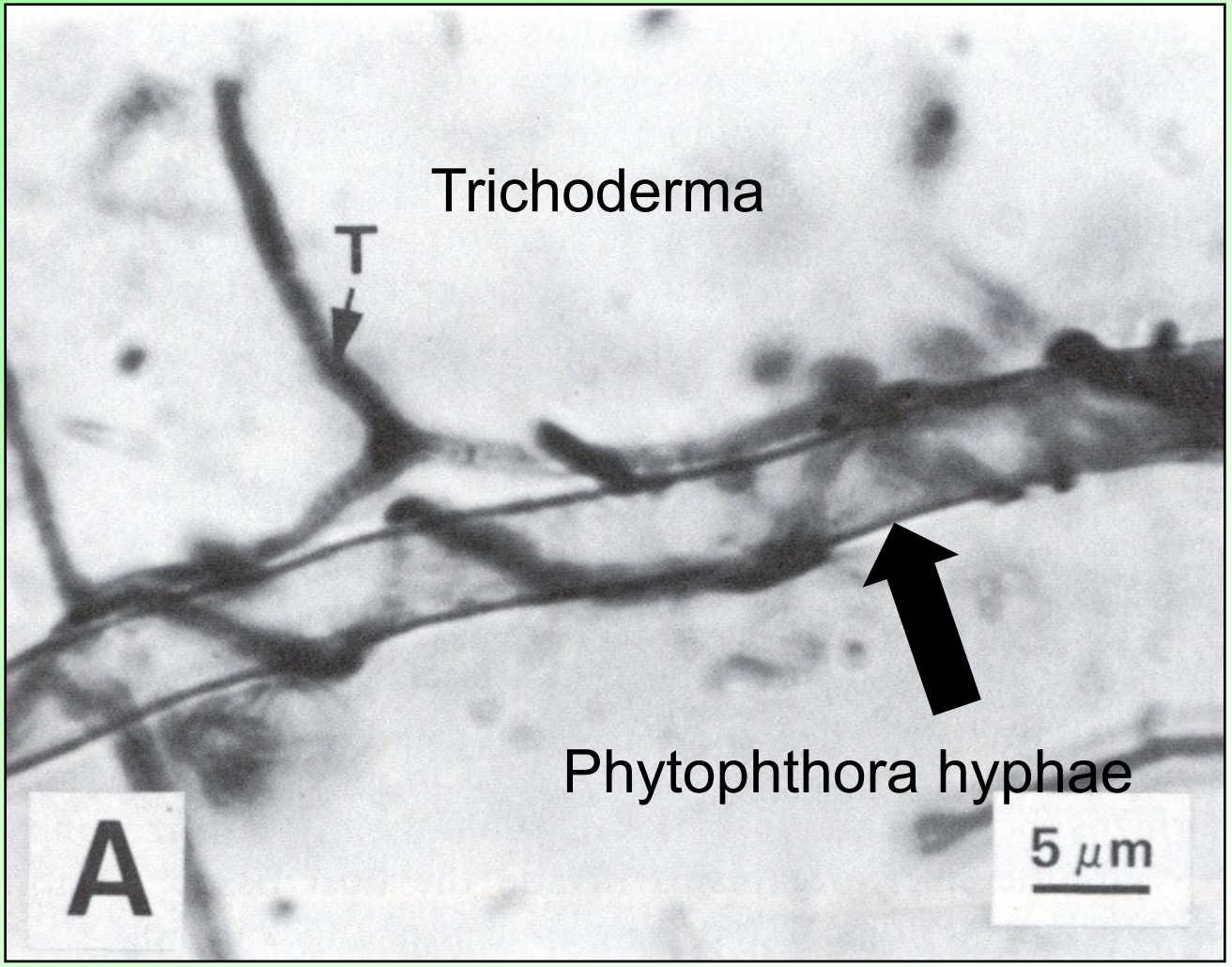
- Organic matter decomposition and nutrient cycling
- Increased nutrient supply to plant roots
- Formation and stabilization of soil structure
- Control of pests and pathogens
- Breakdown of organic contaminants

Principle Soil Decomposers

Microbial Group	*Soil population (cells/gram soil)*
Bacteria	300,000 - 200,000,000
Actinomycetes	100,000 - 100,000,000
Fungi	20,000 - 1,000,000
Protozoa	10,000 - 100,000
Algae	100 - 50,000

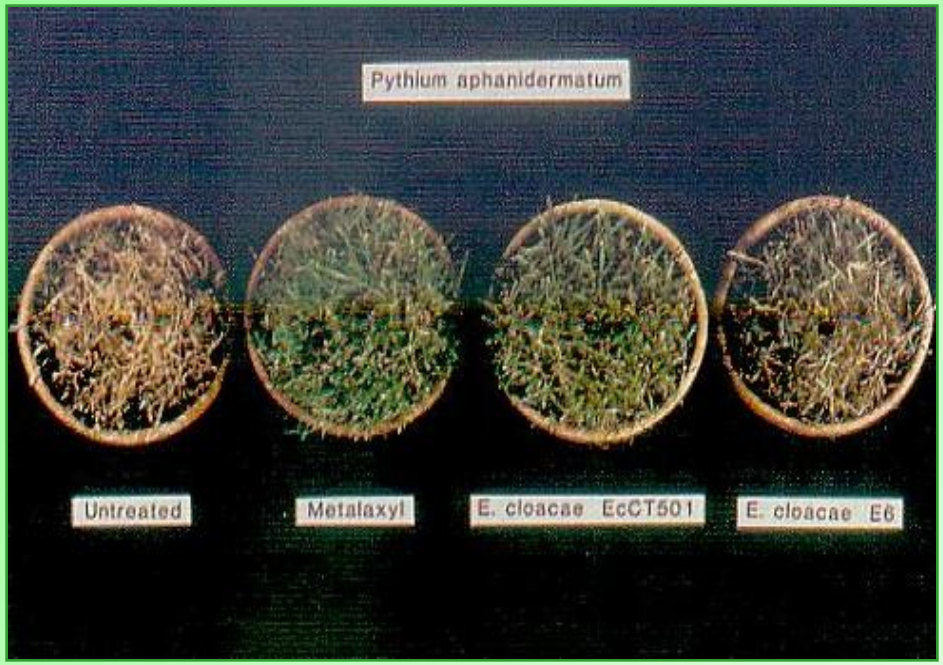
Similar to those in compost. Population and diversity are measures of soil quality

Disease Suppression



Malajczuk, 1983

Suppresses Soil-Borne Diseases



4 Mechanisms of Disease Suppression, via beneficial organisms:

1. Induced systemic resistance (ISR) or systemic acquired resistance (SAR) – turns on plant's natural disease-fighting mechanisms
2. Antagonism (kills/harms disease organisms)
3. Competition for nutrients (and energy)
4. Competition for root colonization

QUESTIONS