# Compost Production and Use

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# Key Questions/Topics For Webinar

- Purpose?  (Why?)
  - Soil amendment, transplants, container growing media, liquid extracts or teas
- How much?  (What?)
  - Rate of application or use?
  - Economics / capital?
- Purchase or Produce? (How)
  - Purchase: Where? How much? What cost?
  - Produce: Feedstocks? Methods?  Vermicomposting?
- Process? (How?)
  - Production
  - Application

# Compost Perspectives and Options

## Product and Process

Compost as a Product

Composting as a Process

Waste Management or Resource Management?

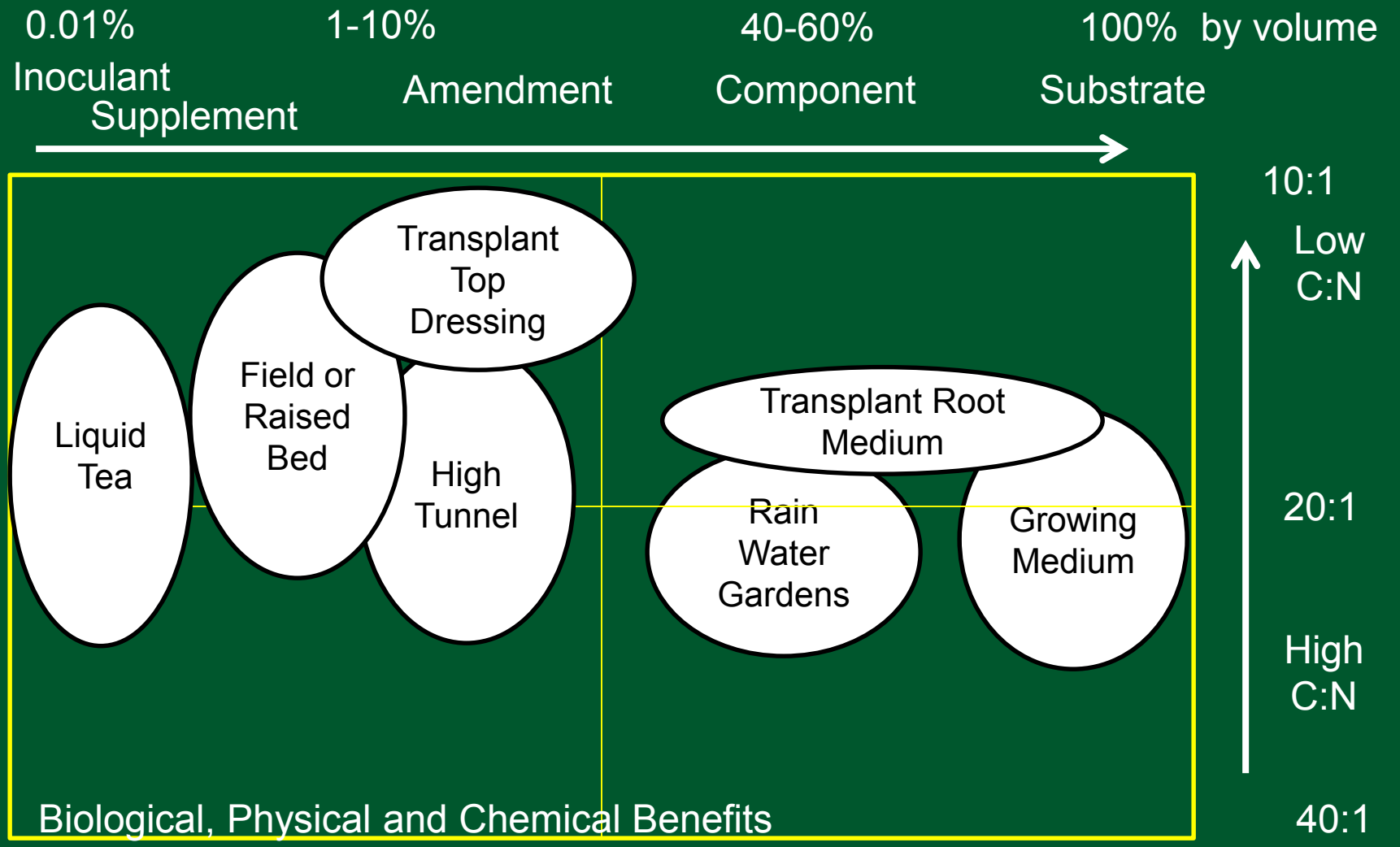
# Why Use Composting?

- Stabilize nitrogen in manure to avoid loss
- Stabilize organic materials to avoid odors or detrimental impact to field soils
- Reduce volume and or moisture to concentrate nutrients and ease transport
- Make a wide range of organic material more valuable & marketable off farm
- Close the Food Cycle - Back to the Farm
- Make a valuable resource for amending soils, growing transplants, or for container growing root media

# Why Use Compost?

- Microbial diversity
  - Inoculation and food source
- Soil Organic Matter (SOM) & humus
  - Water absorption and retention
  - Drought tolerance, reduced erosion
- Plant nutrients (N,P,K) fast and slow
- Increased cation exchange (CEC), pH buffer
- Root and Foliar Disease Suppression
- Component of potting media for transplants
- Container growing medium
- For  plant health with compost tea

# Compost Uses and Applications



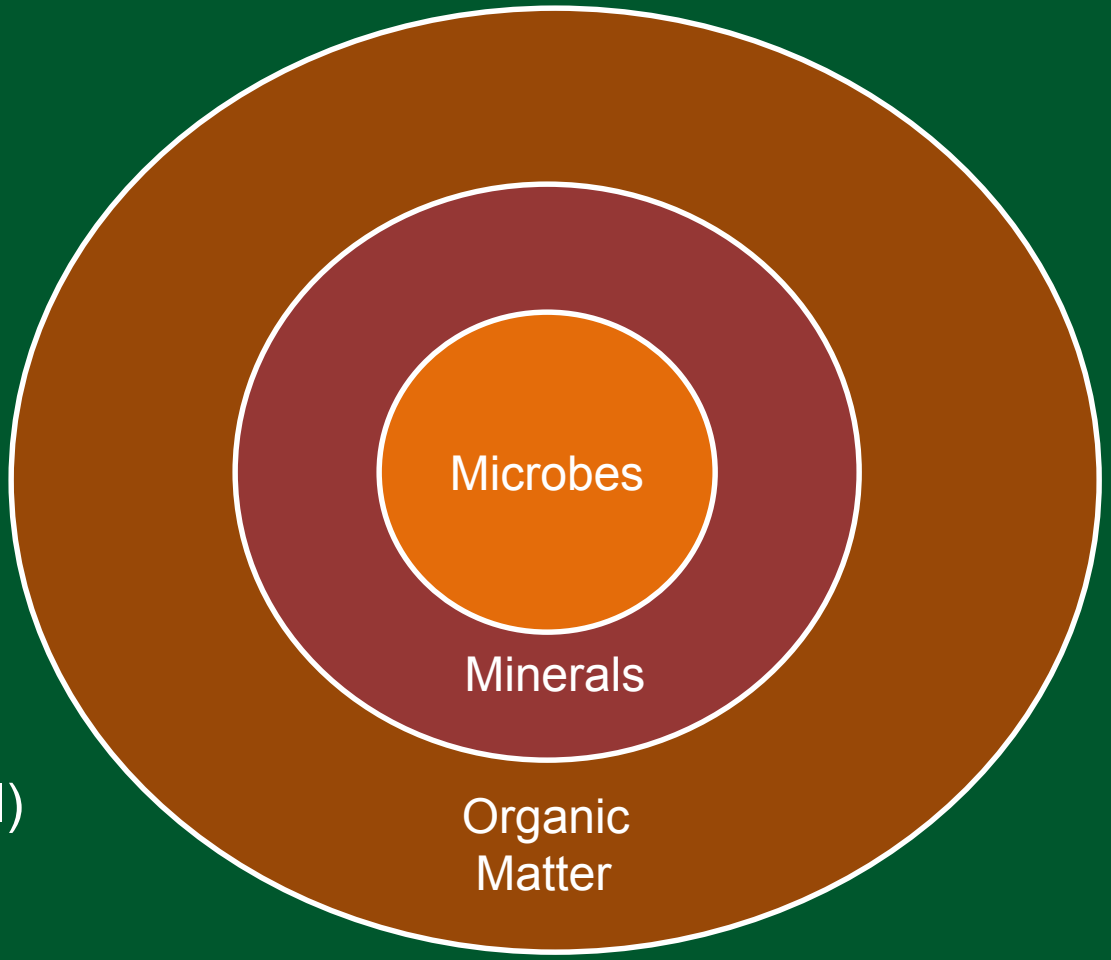

1 ton/acre compost is approximately 0.25% by volume AFS or 0.1% by weight.
4 ton/acre is approximately 1% by volume and 10 ton/acre is 1% by weight.

# Compost Uses – WHY?

Microbes (Biological)
- Mineralization
- Nutrient Cycling / Storage
- Disease Management

Minerals (Chemical)
- Exchange Capacity
- pH - Availability
- N, P, K, Ca, Mg, S
- Fe, Mn, Zn, Cu, B, Mo
- Si, Al, Ni, etc

Organic Matter (Physical)
- Available Carbon
- Stable Carbon / Humus
- Aggregation and Water Holding



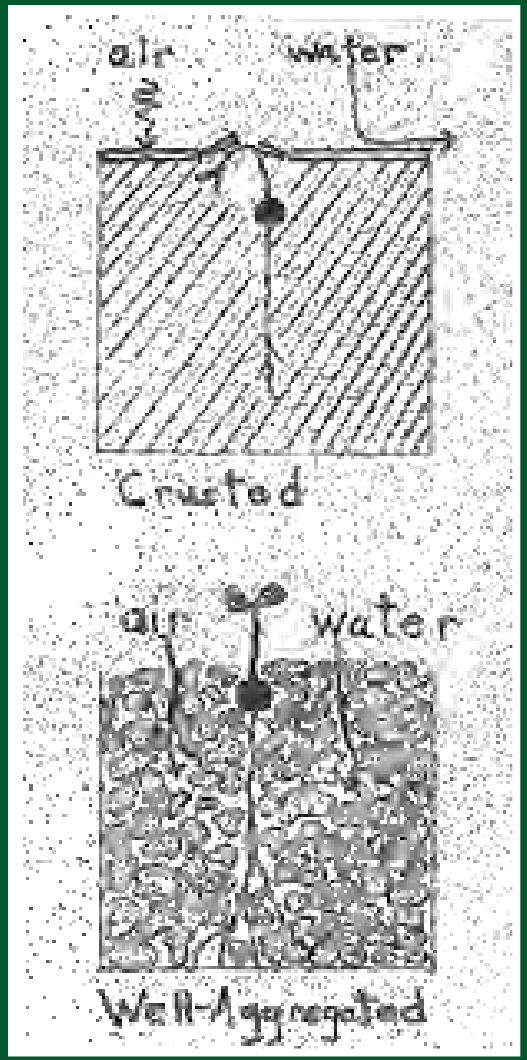
# How many pounds (lbs) of Soil Organic Matter (SOM) per acre?

- Acre furrow slice = 2,000,000 lbs of soil
- 1% of weight =  20,000 lbs
- 10 ton of compost = 20,000 lbs so 1% OM if stable and does not decompose quickly

# SOM/Compost Contributions to Physical Properties

- Increased water absorption
- Increased water retention
- Improved drought tolerance
- Reduced soil erosion
- Improved root health

# Organic Matter Increases Water Absorption and Retention




**From Attra Publication**

# Water Absorption Increases

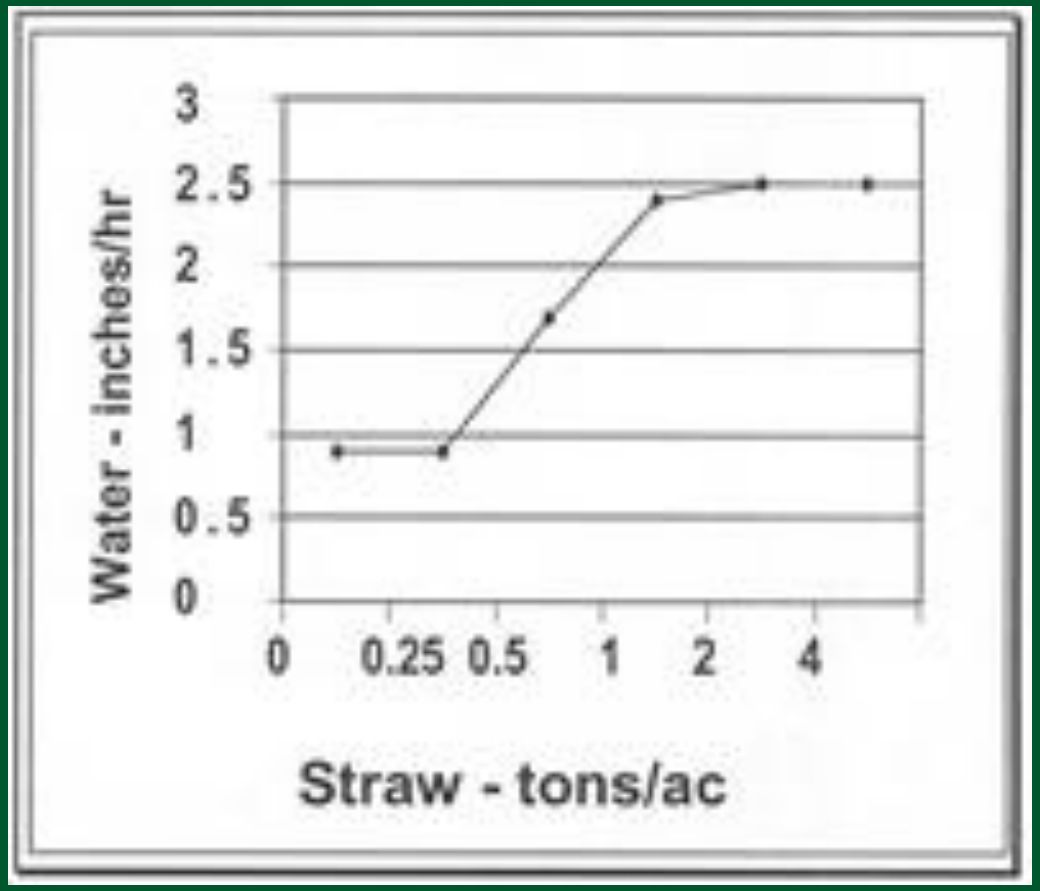
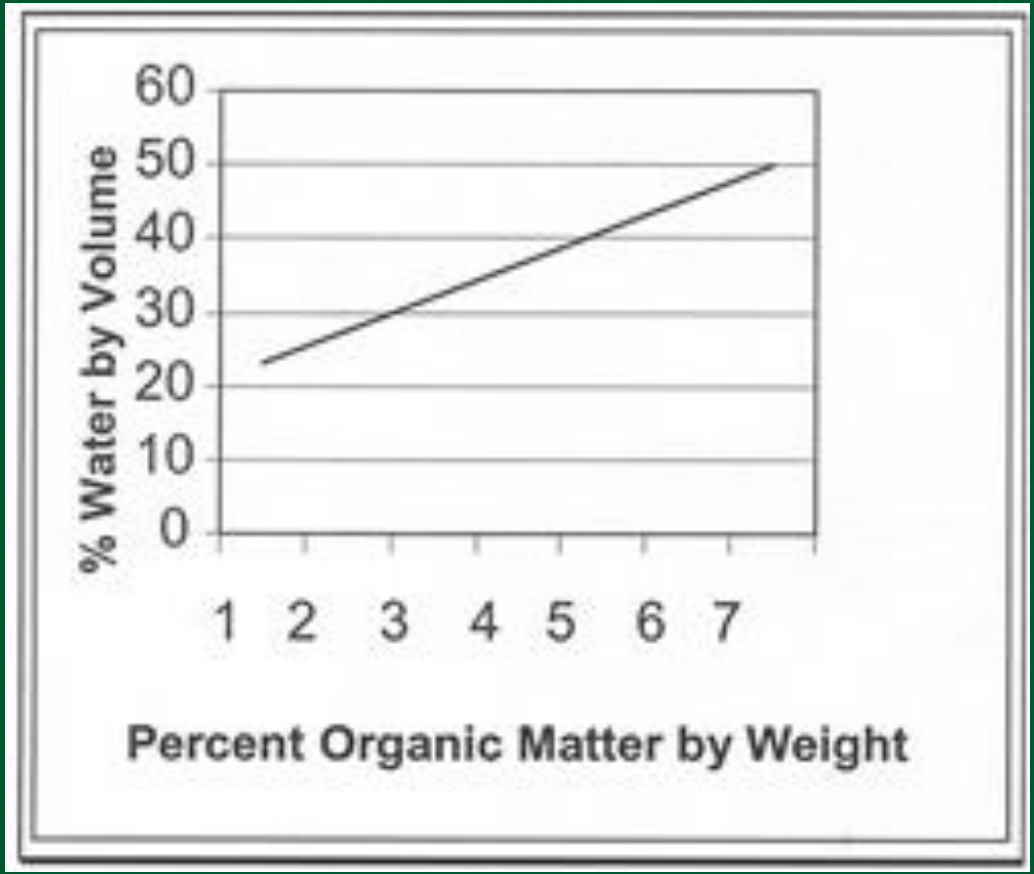



Figure 3. Effect of straw rate on water infiltration on a silt loam soil.

# Water Retention Increases




Available water content with increasing soil organic matter.

# SOM/Compost Contributions to Soil Chemical Properties

- Readily available nutrients (N, K, Ca, ?)
- Slowly releases nutrients (N,P,K, Ca, Mg, S)
  - With 1% SOM, that may contain 1% nitrogen, decomposing at 10% per year, that's potentially 20 lbs of soil available nitrogen per acre over the growing season
- Micronutrients
- Soil pH
- Cation Exchange Capacity (CEC)

# Rates of Compost Application

| Rate | Cu yd/ acre | Ton/ acre | Cu ft/ 100 sqft | Gal/ 100 sqft | Inches deep | Lbs N (1%N) |
|---|---|---|---|---|---|---|
| Low | 2 | 1 | 0.1 | 0.75 | dusting | 20 |
| Mod | 5 | 2.5 | 0.25 | 2 | dusting | 50 |
| Mod | 10 | 5 | 0.50 | 4 | 0.075 (1/16) | 100 |
| High | 20 | 10 | 1.0 | 8 | 0.12 (1/8) | 200 |

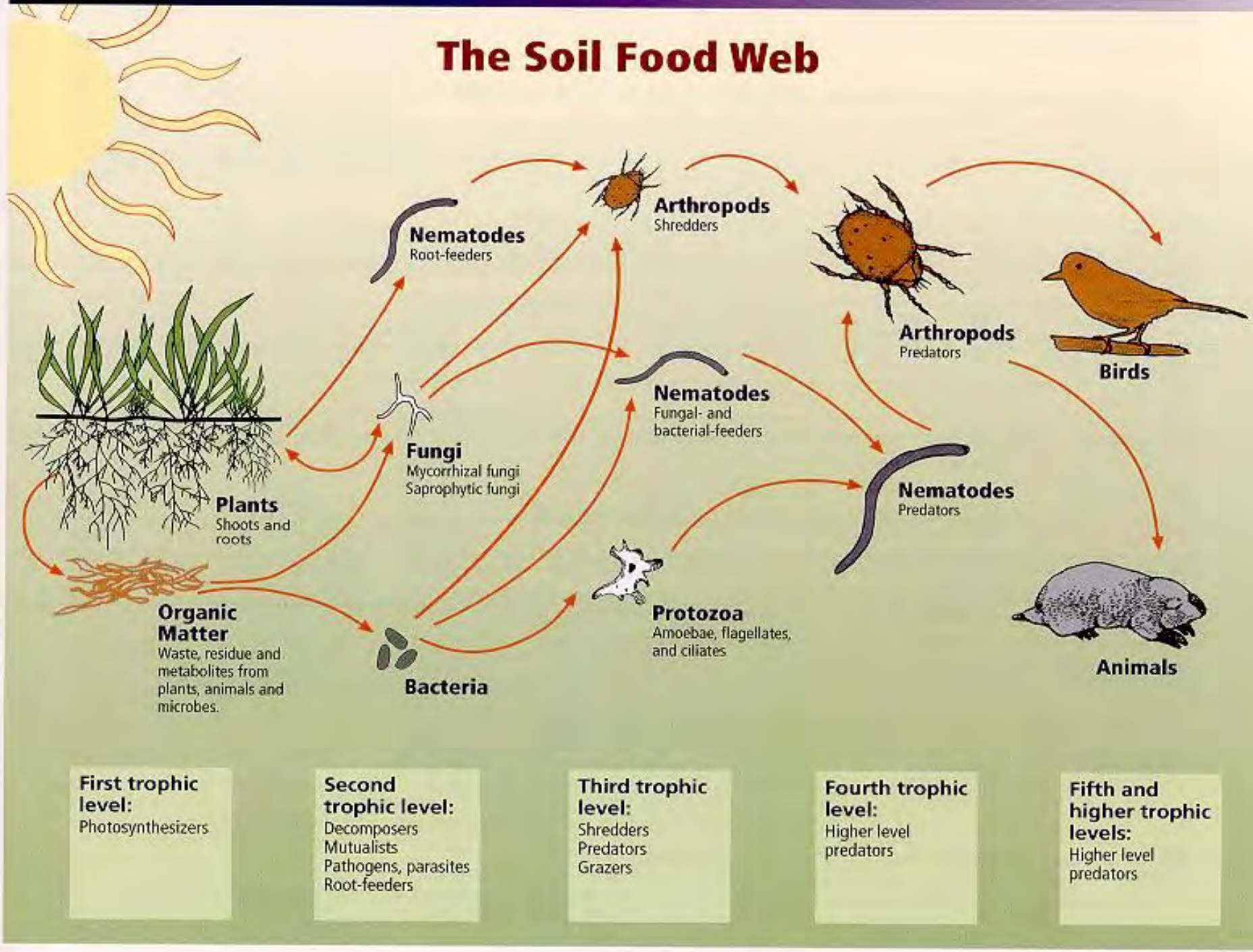
Only part of the nitrogen is available each year.
Assumes moist weight of 1000 lbs/cu yd
Not exactly equivalent rates due to rounding.

# Does just estimating the amount of NPK applied explain the benefits of compost?

A common portrayal of organic farming and gardening is that you can't apply enough nutrients by applying organic matter or compost.

To understand how compost works, it is important to see why it is not the same as fertilizer. The biology provided and supported gradually provide nutrients.

# The Soil Food Web




**First trophic level:**
Photosynthesizers

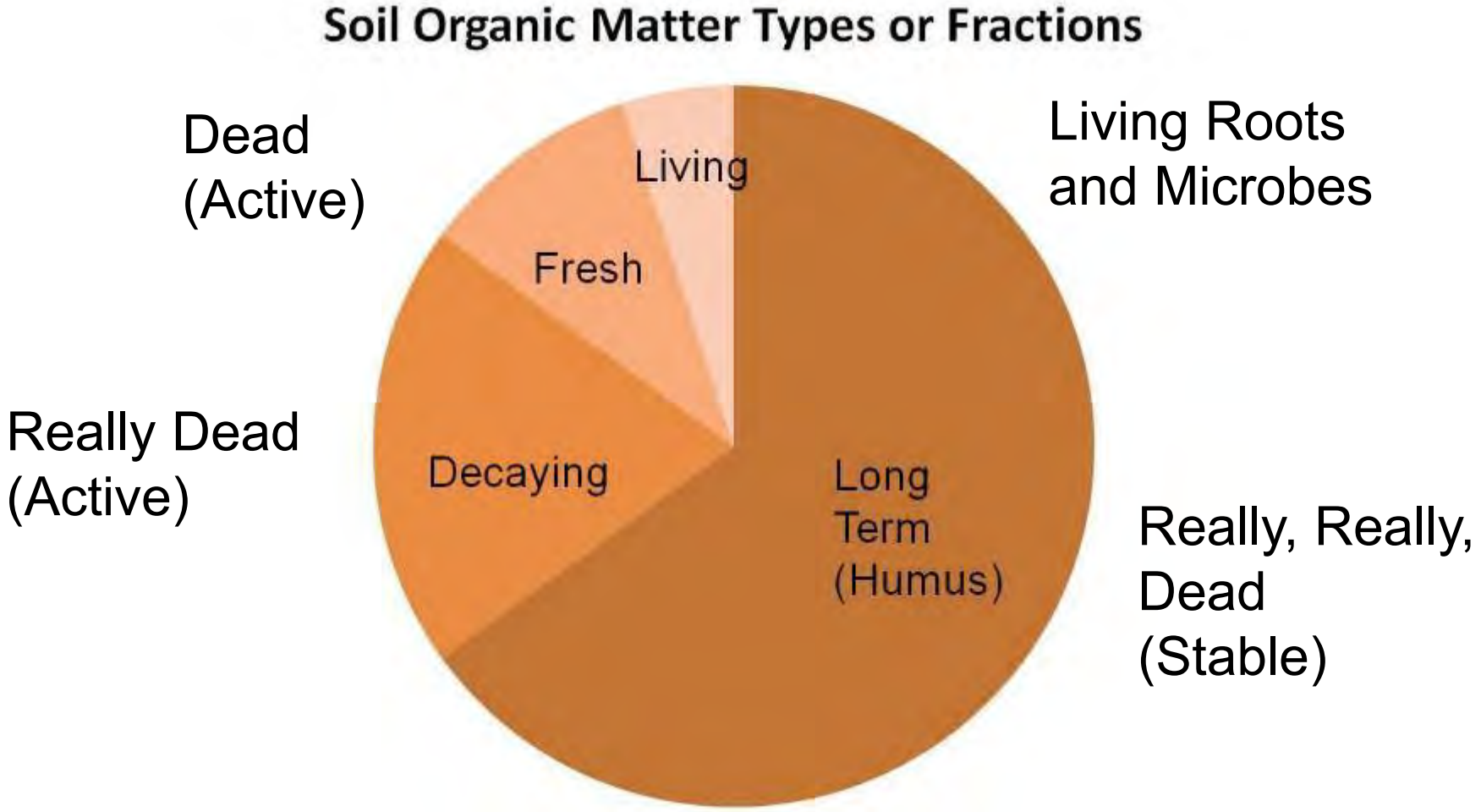
**Second trophic level:**
Decomposers
Mutualists
Pathogens, parasites
Root-feeders

**Third trophic level:**
Shredders
Predators
Grazers

**Fourth trophic level:**
Higher level predators

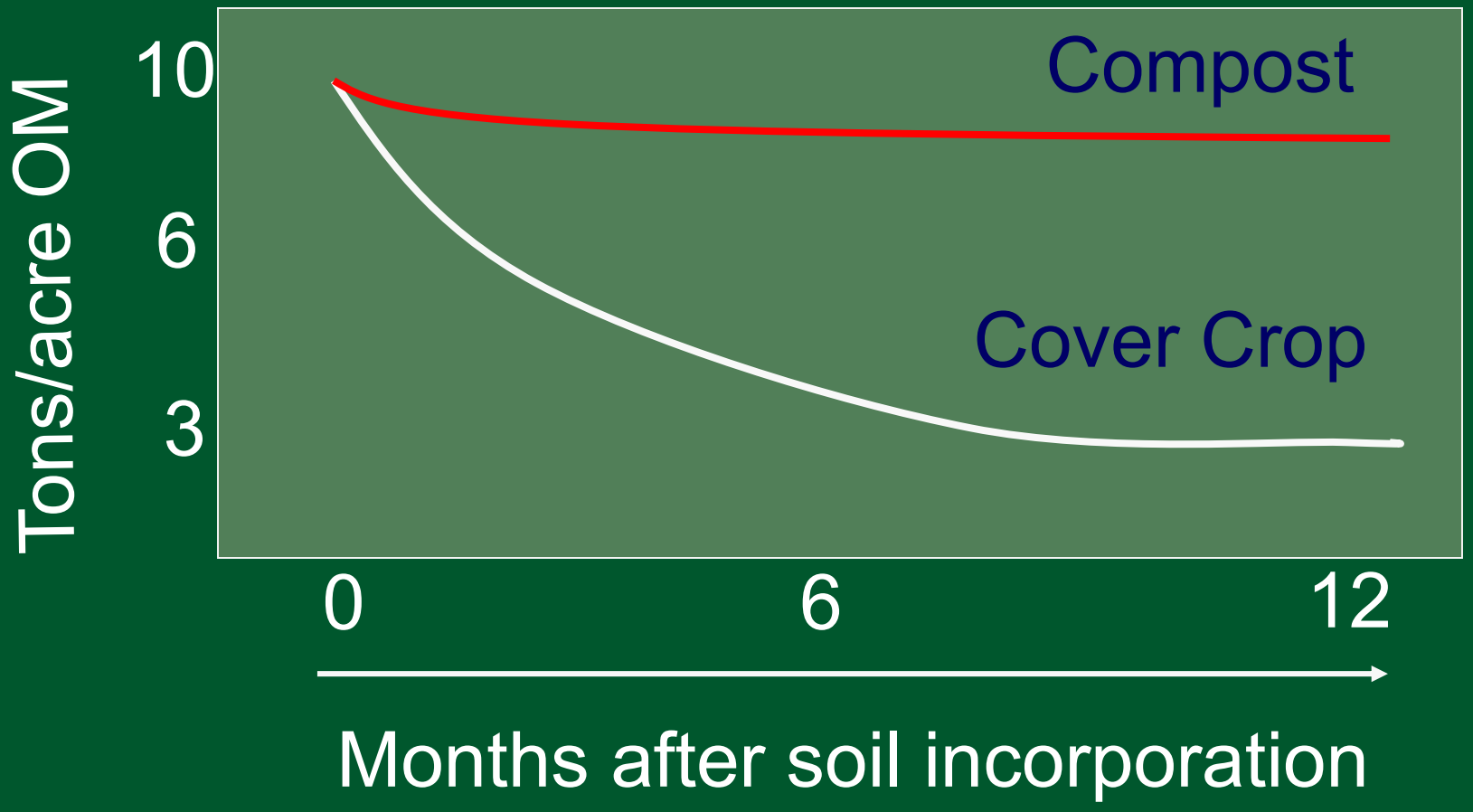
**Fifth and higher trophic levels:**
Higher level predators

# To improve soil quality, a mixture of organic matter types (ages) is key!



# Compost vs. Cover Crop

## Effects on SOM



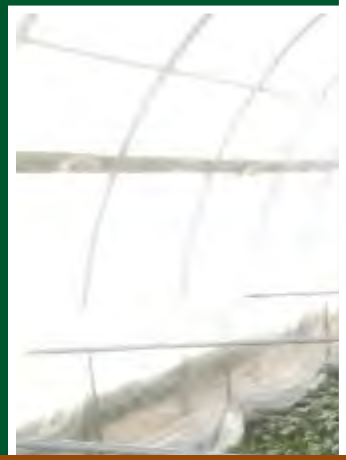

Rye-Vetch
No Compost
Big Beef


Rye-Vetch
Compost
Big Beef

# Compost Top Dressing to Transplants


7

# High Tunnels



5 gal bucket / 20 sq ft  to
1 cubic foot/ 20 sq ft (7.5 gal)

5 cubic foot / 100 sq ft
3 to 4 cu yd/ 30x96 hoophouse

80 yd/acre or 40 ton/acre

No leaching from rain
No freezing of the ground

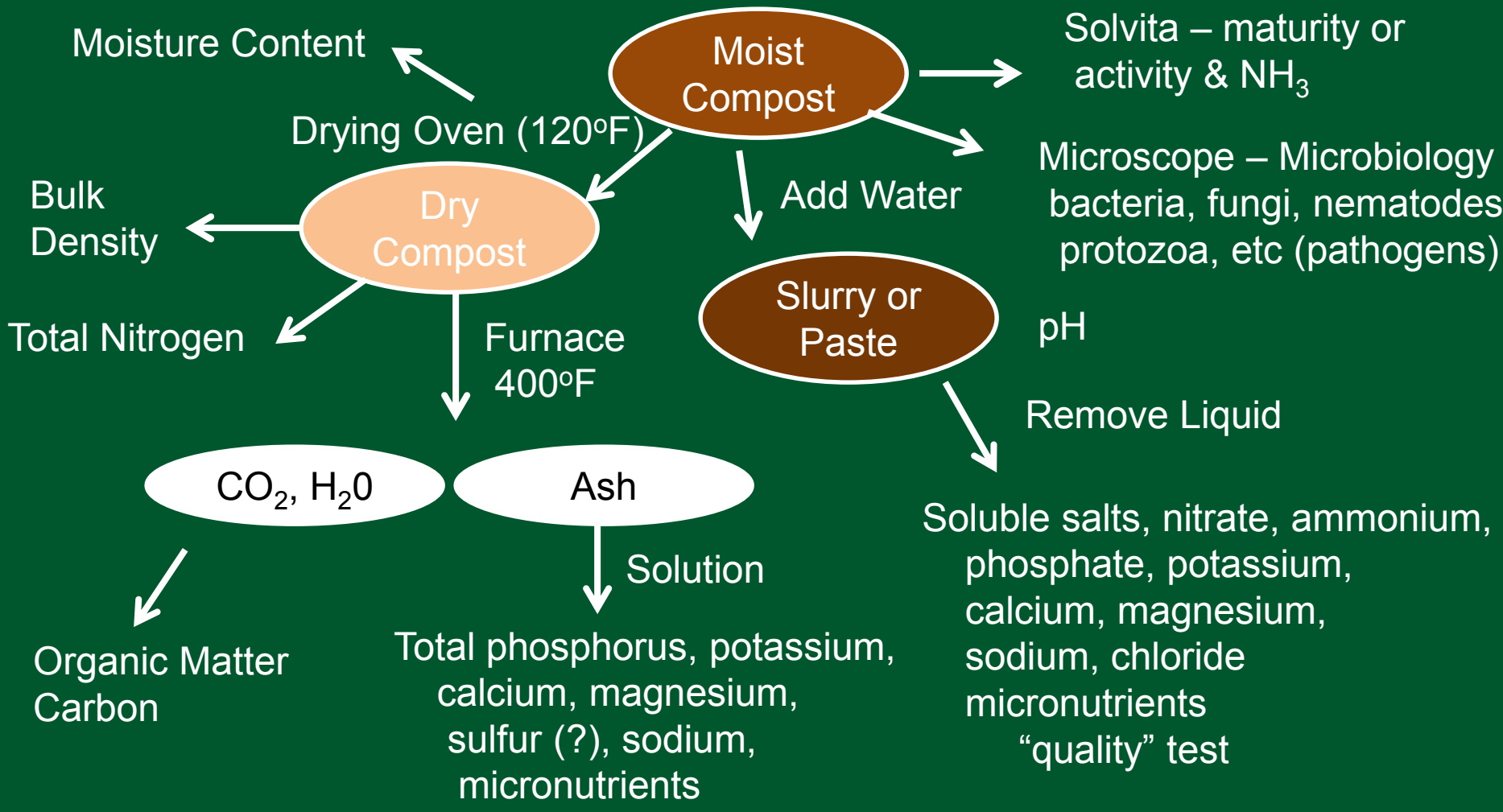
# Purchase or Produce?

- If you can buy good compost when starting out farming, most would say do it.
  - Can you find good compost to purchase?
  - What might compost cost? Transportation?
- Depends in part on how much you need?
  - What is a reasonable rate of application?
  - Depends on the situation / crop / soil
    - Range from 1 (field crops) to 10 (vegetables) to 40 (high tunnels) ton/acre

# Michigan Sources of Compost

- Search for Bulk Compost in Michigan
- Search for Registered Compost Sites
- Some Examples:
  - Morgan's Dairy Doo (Evert)
  - Tuthill Farms and Composting (South Lyons)
  - Indian Summer Recycling (North Detroit)
  - McKay's Compost (Flint area)
  - Herres Compost  (Novi area)
  - Hammond Farms (Lansing)
  - Renewed Earth (Kalamazoo)
  - SOCCRA
  - Marquette County Landfill
- Bioassay and Test Before Using!

# Compost Analysis and Testing

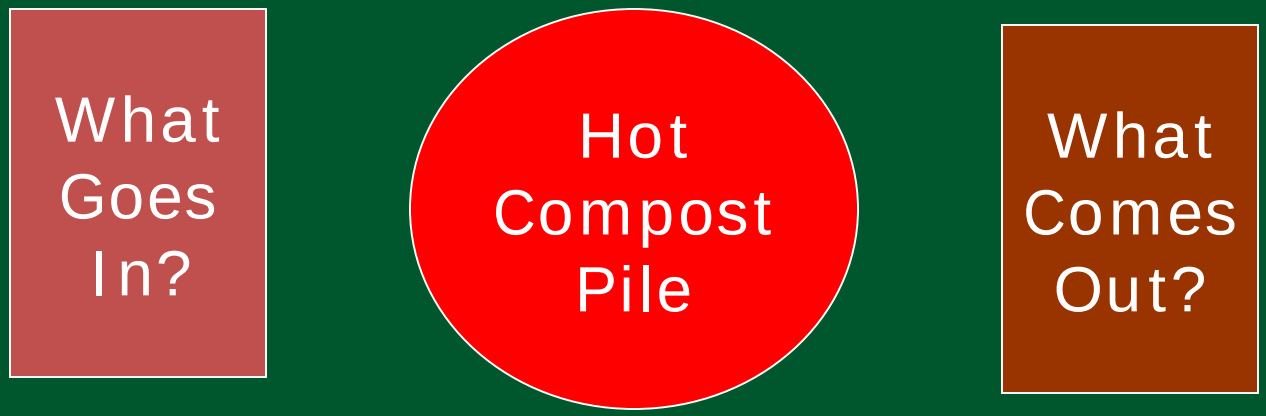


# Herbicides in Compost

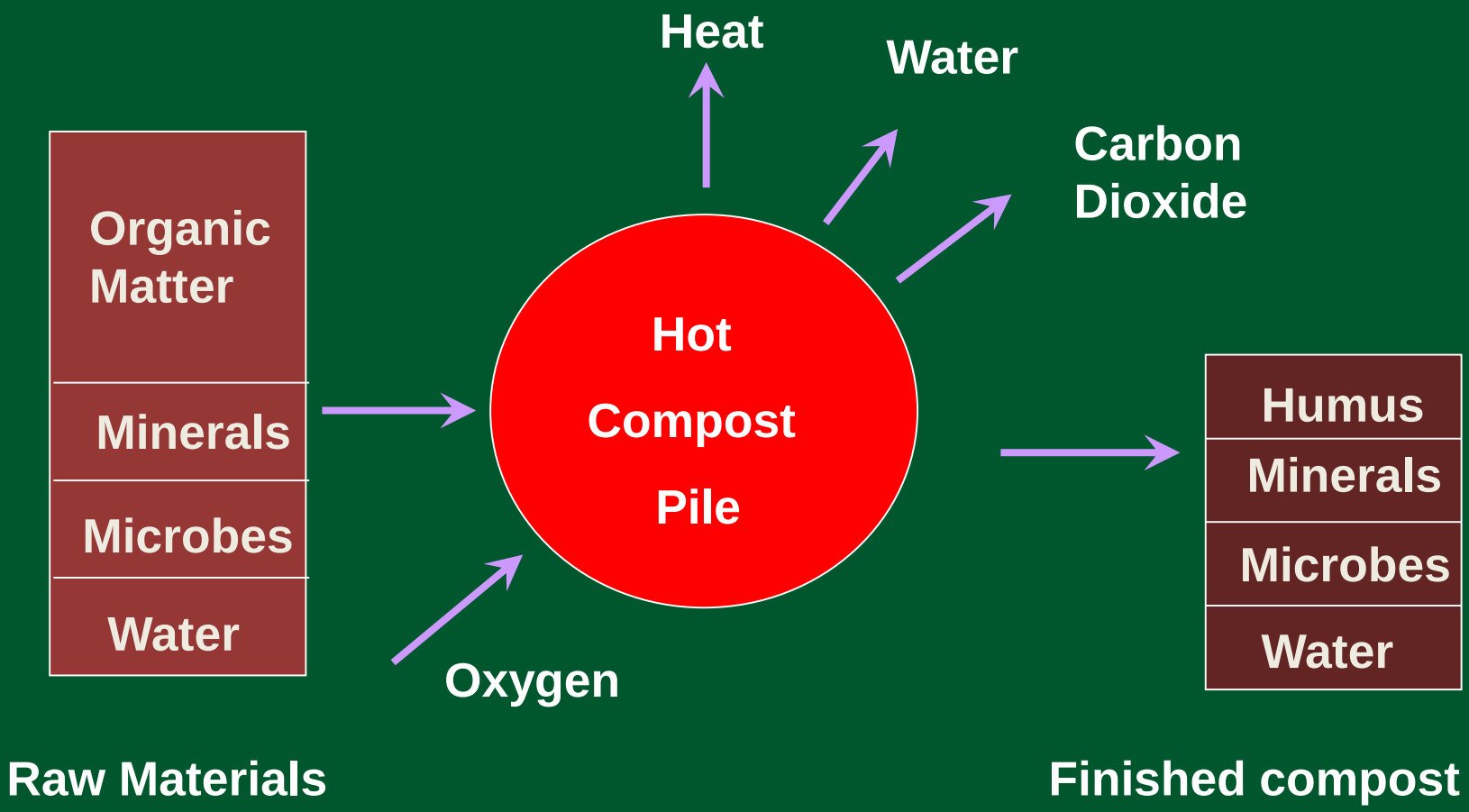
# Farm Bioassay of Compost

- Purity and Maturity
  - Place in flat, moisten and check for seed contamination / germination
  - Place in flat, sow seeds and check for inhibition (tomato, cucumber, bean, kale)
- Weight or Bulk Density
  - Weight of 5 gallon bucket x 40 = lbs cubic yard  (if moist, 800 light, 1000 avg, 1200 high)
  - Estimate of how much carbon – lighter more

# What is the simplified compost process?



# The Composting Process



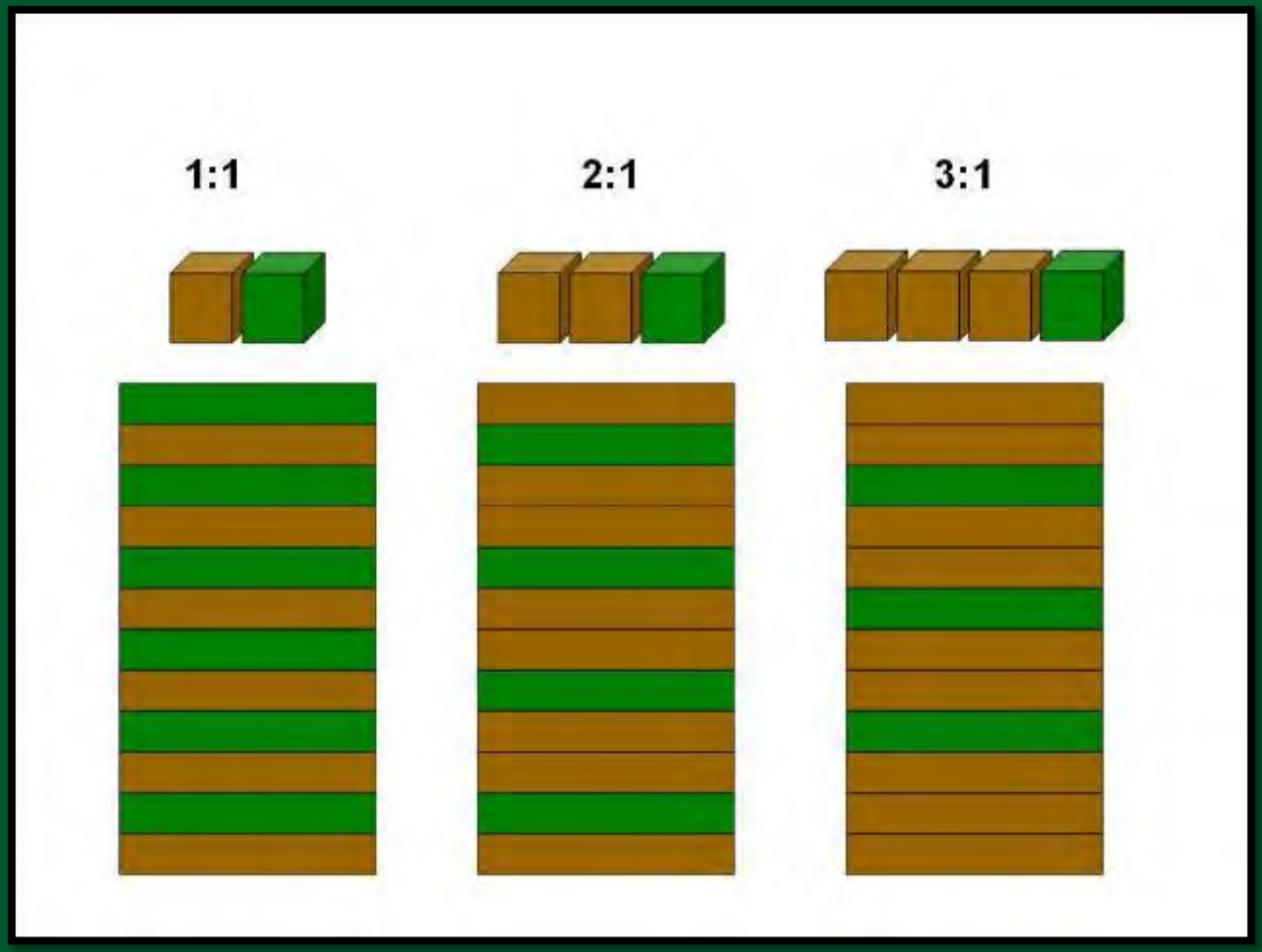
# Seven Manageable Factors

- Food: Substrate or Feedstock
  - Particle size has important influence
- Air: Oxygen (Porosity)
- Water: Moisture
- Temperature
- pH
- Microbes present
- Time – fast or slow, when to stop

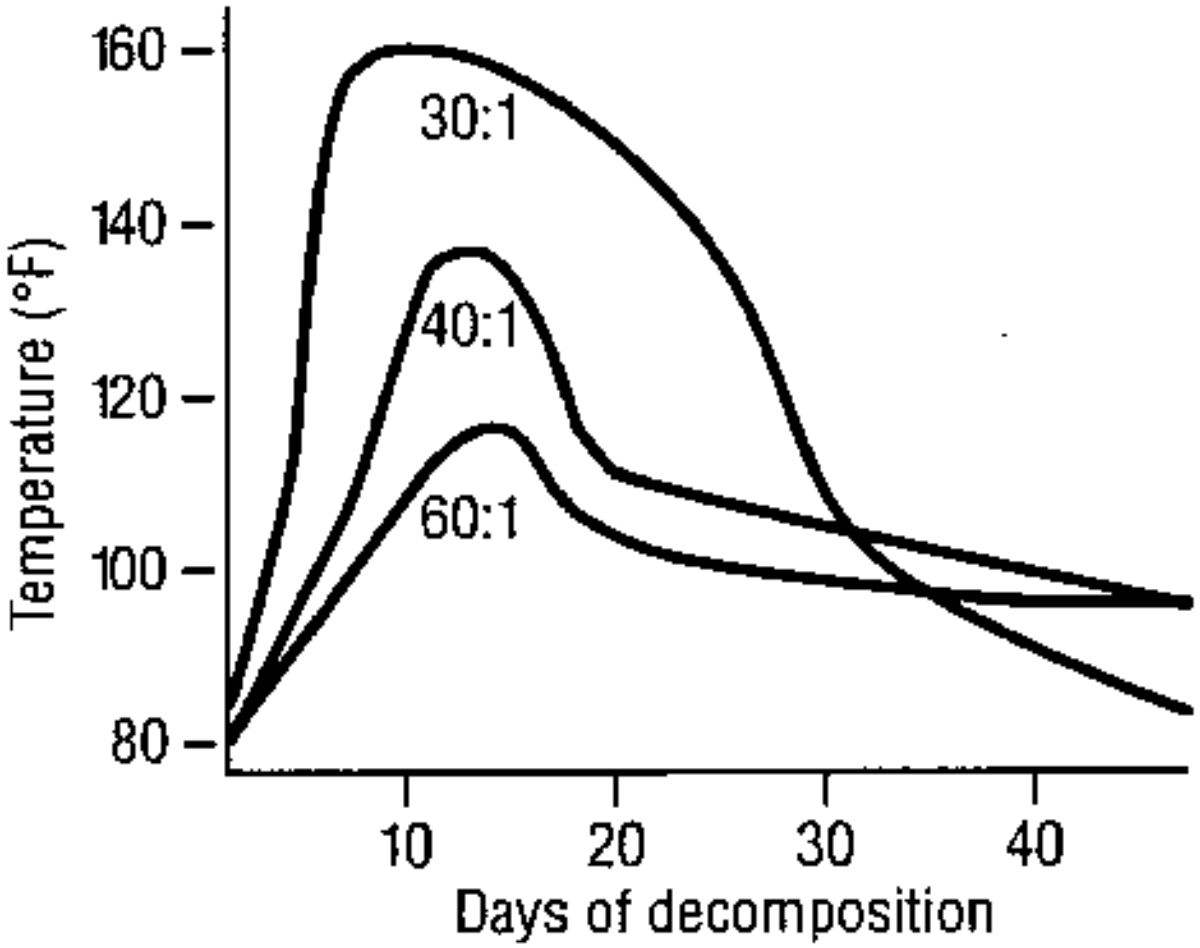
# Feedstock C:N Ratios

| **Brown / High in Carbon** | C:N Ratio |
|---|---|
| Fall leaves | 30-80 |
| Straw | 40-100 |
| Wood chips or sawdust | 100-500 |
| Bark | 100-130 |
| Mixed paper | 150-200 |
| Newspaper or cardboard | 560 |
| **Green / High in Nitrogen** | C:N Ratio |
| Hay or Grass clippings | 15-25 |
| Vegetable wastes | 15-20 |
| Coffee grounds | 20 |
| Manure | 5-25 |

# Ratio of Brown to Green



# Carbon:Nitrogen Ratio Effects on Composting



# Squeeze Test for Moisture Content

- If it releases a “stream” of water, moisture is >65%
- Ideal moisture content is 50-60%; “A squeezed handful of compost should leave the skin wet but not release more than a drop or two of water” (Brodie et al., 1994)
- If squeezed handful of compost falls apart, moisture is below 45%;

Dry

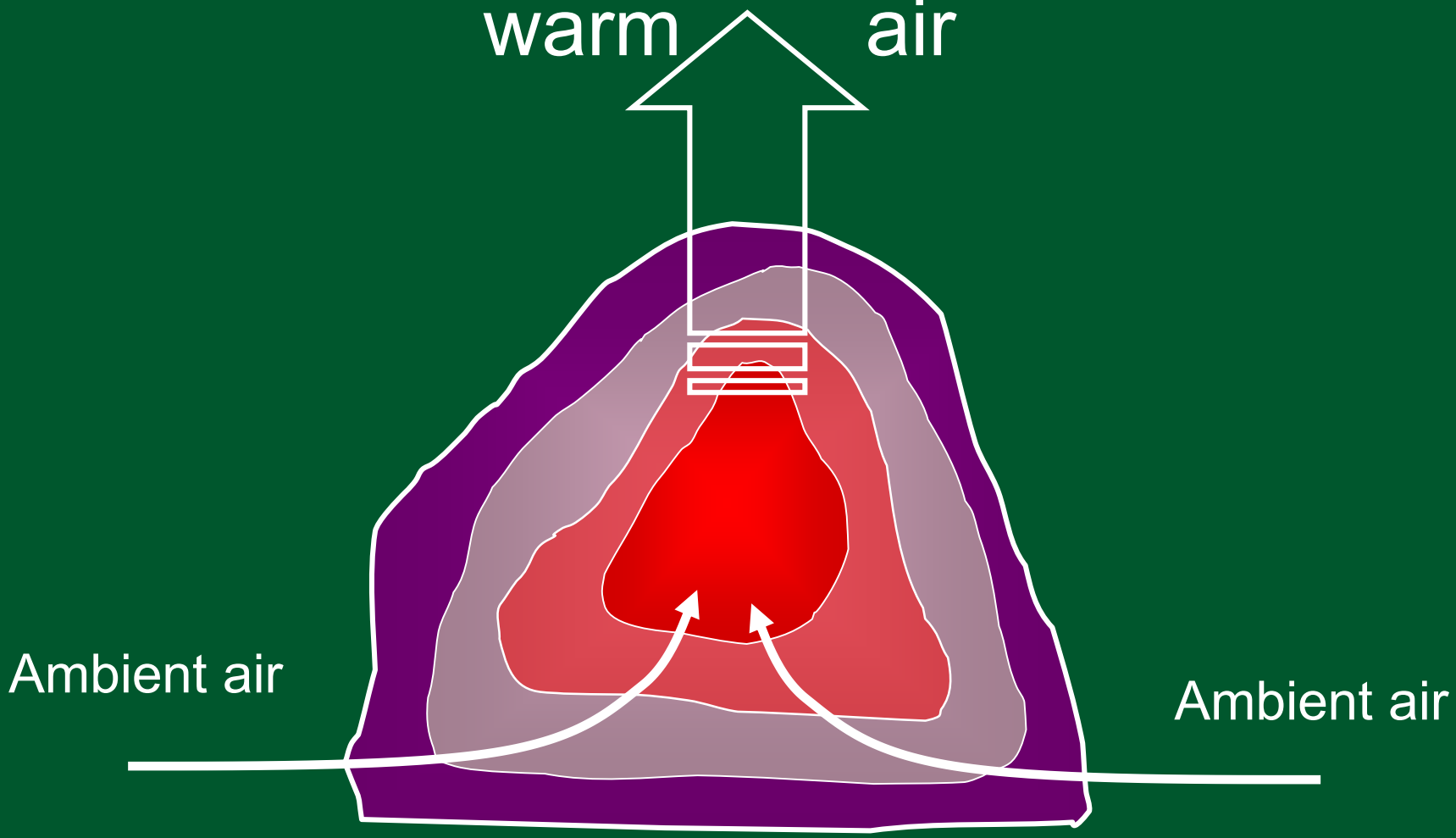
Moist

Wet

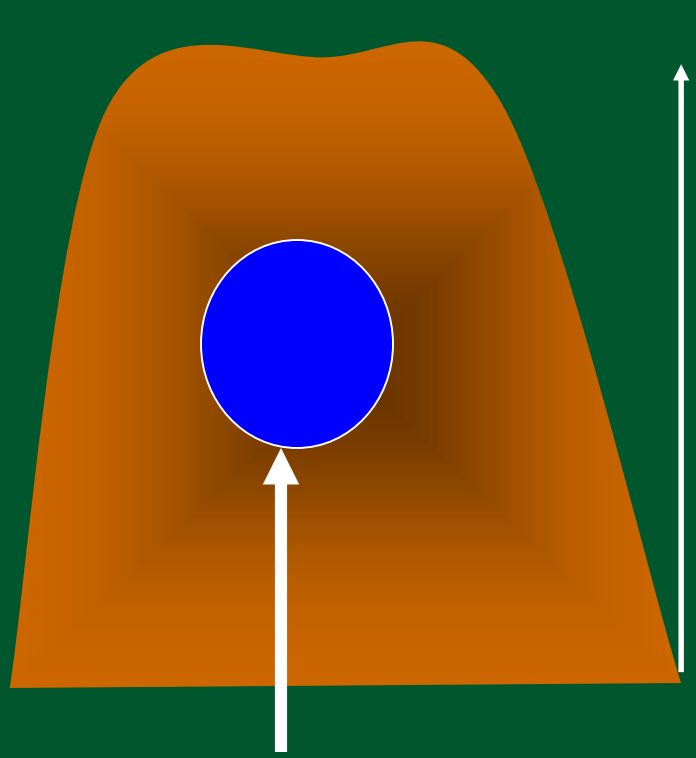
# Compost Moisture Squeeze Test

http://agriculture.vic.gov.au/__data/assets/image/0005/197096/compost-2.jpg

# Convective aeration

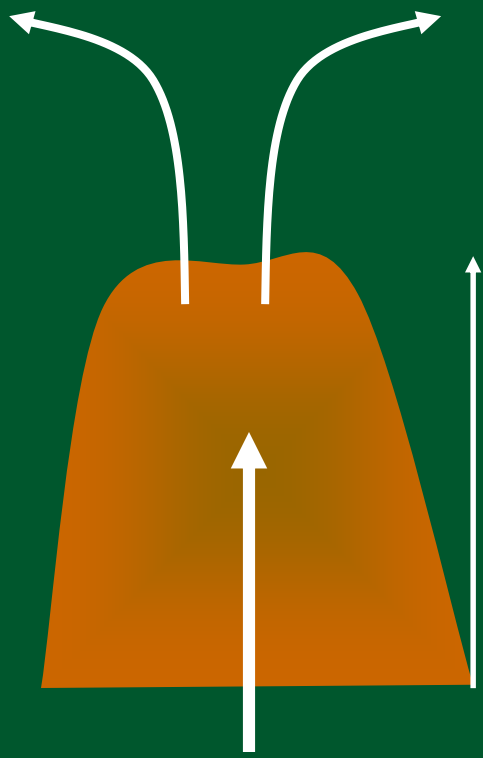


# Air Flow and Pile Size



>10 ft.

No $O_2$



6-8 ft.

Adequate $O_2$

# Compost thermometer is one of the most important tools of the trade.

# Simple way to Measure

- Estimate with hand – if too hot to hold a bare hand in the pile, then temperature is likely over 130F.
- If very hot to the touch but can hold hand in pile for up to 10 seconds, probably in the 110-120F range.

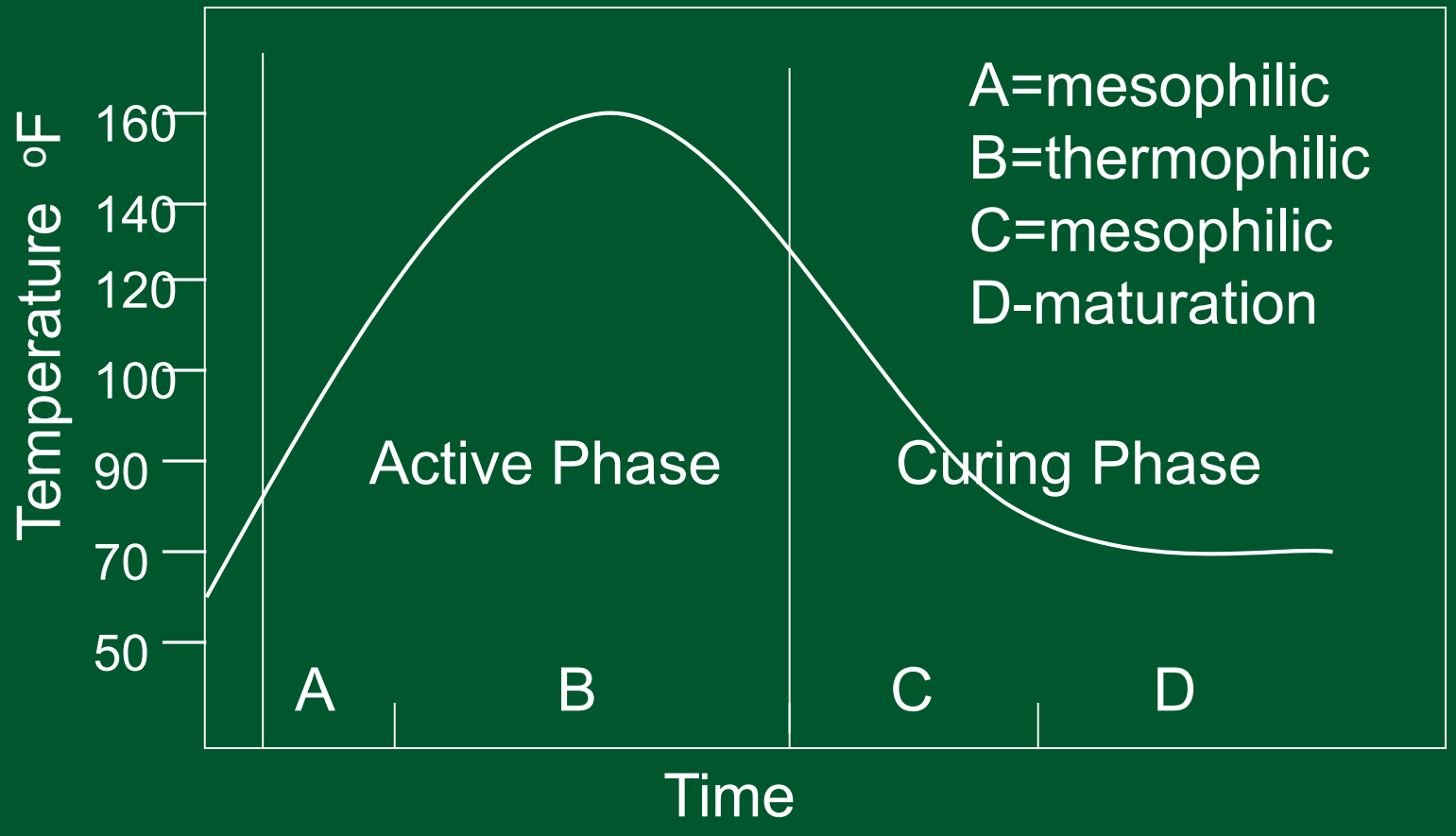
# Managing Temperature

- Pile size; if too hot, spread out
- Lower temp – greater microbial diversity and N retention
- Higher temp – more pathogen and weed seed kill, maybe faster composting
- Recommendation is 3 days at 130$^{o}$F or greater for minimizing seeds and possible human pathogens

# Who are the microbes?

- Bacteria
- Actinomycetes
- Fungi
- Amoeba
- Protozoa
- Nematodes
- Together are the "Soil Food Web"

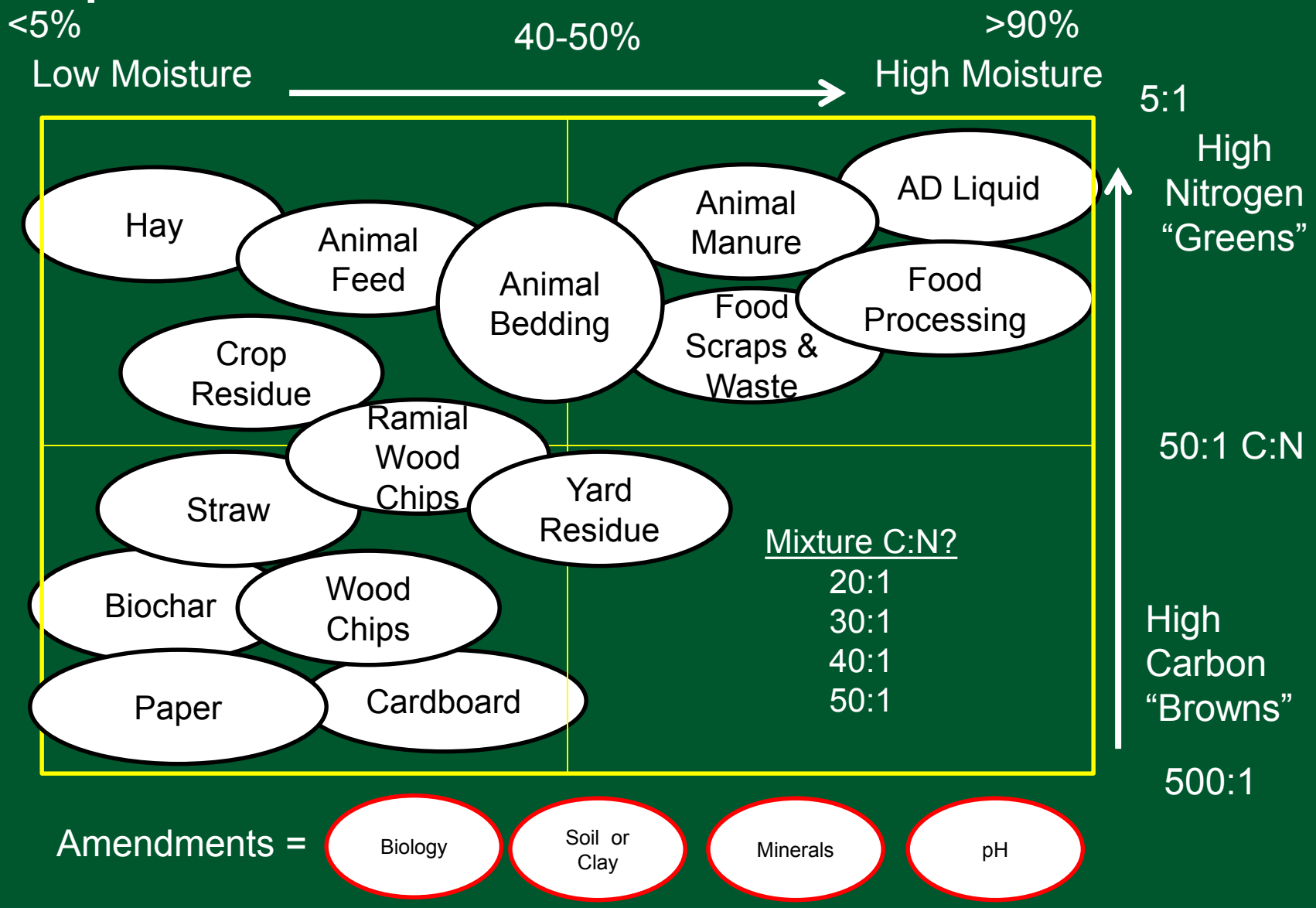
# Microbial Populations Change Over Time



# Effects of Time

- Faster composting, more turning, greater potential for C and N loss
- A range of methods exist
  - Rapid with much turning
  - Slow with minimal or no turning
  - Vermicomposting is lower temperature yet still seems to progress rapidly

# Compost Feedstocks and Amendments



# Feedstock C:N Ratios

| Materials High in Carbon | C:N Ratio |
|---|---|
| Fall leaves | 30-80 |
| Straw | 40-100 |
| Wood chips or sawdust | 100-500 |
| Bark | 100-130 |
| Mixed paper | 150-200 |
| Newspaper or cardboard | 560 |
| **Materials High in Nitrogen** | **C:N Ratio** |
| Vegetable wastes | 15-20 |
| Coffee grounds | 20 |
| Grass clippings | 15-25 |
| Manure | 5-25 |

| Material | C:N Ratio | % Carbon | % Nitrogen | % Moisture Content | Bulk Density (lbs/cu yd) |
|---|---|---|---|---|---|
| Veggie "wastes" | 12-19 | 40-50 | 2.5-4 | 87 | 1,585 |
| Hay - general | 15-32 | 40-50 | 0.7-3.6 | 8-10 | 225 |
| Grass clippings | 9-25 | 40-50 | 2.0-6.0 | 82 | 300-800 |
| Dairy cat manure | 11-30 | 30-40 | 1.4-4.2 | 67-87 | 1,323-1,674 |
| Lay hen manure | 3-10 | 30-40 | 4-10 | 62-75 | 1,377-1,620 |
| Turkey litter | 16 | 40-45 | 2.6 | 26 | 783 |
| Apple pomace | 48 | 45-55 | 1.1 | 88 | 1,559 |
| Corn stal, mature | 60-73 | 40-55 | 0.6-0.8 | 12 | 32 |
| Straw - general | 48-150 | 45-55 | 0.3-1.1 | 4-27 | 58-378 |
| Sawdust | 200-750 | 45-60 | 0.06-0.8 | 19-65 | 350-450 |
| Leaves | 40-80 | 40-55 | 0.5-1.3 | 38 (average) | 300-800 |

# Fall Leaf Pick –Up with Raking or Mowing

# Collecting Feedstocks on a Larger Scale

# NRCS EQIP Funding for Composting

Feedstock Storage

# A Variety of Materials Can Improve Final Quality




# Unfed or Molded Hay

# Straw Roundbales

# Off Farm Materials to Consider

- Coffee Grounds
- Food Scraps – Kitchen Preparation
- Food Waste – Cooked, likely containing meat, pasta, rice, dairy, etc
- Spent Brewery Grains
- Wood Chips
- Municipal Leaves

# Truck used to haul produce from grocery stores to a compost facility

# Expired Produce from a Grocery Store

# “Pulping” is a method of handling post consumer materials – large garbage disposal


# Pulped  Post Consumer Food Waste

# Mixing feedstocks and pulped food residue

# Food Scraps and Coffee Grounds and filters on Bed of Municipal Leaves

# Municipal Leaves

# Harvesting Hay or Grass

# Flail Mower


DAKOTA

# Mixtures: 2L:1G 1L:1G 1L:2G

L= leaves G= grass

# Pear Tree Farm (PTF) Transplant & Tea Mix

## Goal: plant based, non-manure, reproducible

Amount of comfrey and soil shown used per bale of others.


These components are readily available to make a reproducible mix with moderate N


6 hay @ $3 = $12
3 straw @ $2 = $6
3 shaving @ $6 = $18
3 peat @ $10 = $30
Total = $66
JP McCrumb
FINE PINE
PREMIER
PEAT MOSS

# Similar Mixture on Larger Scale

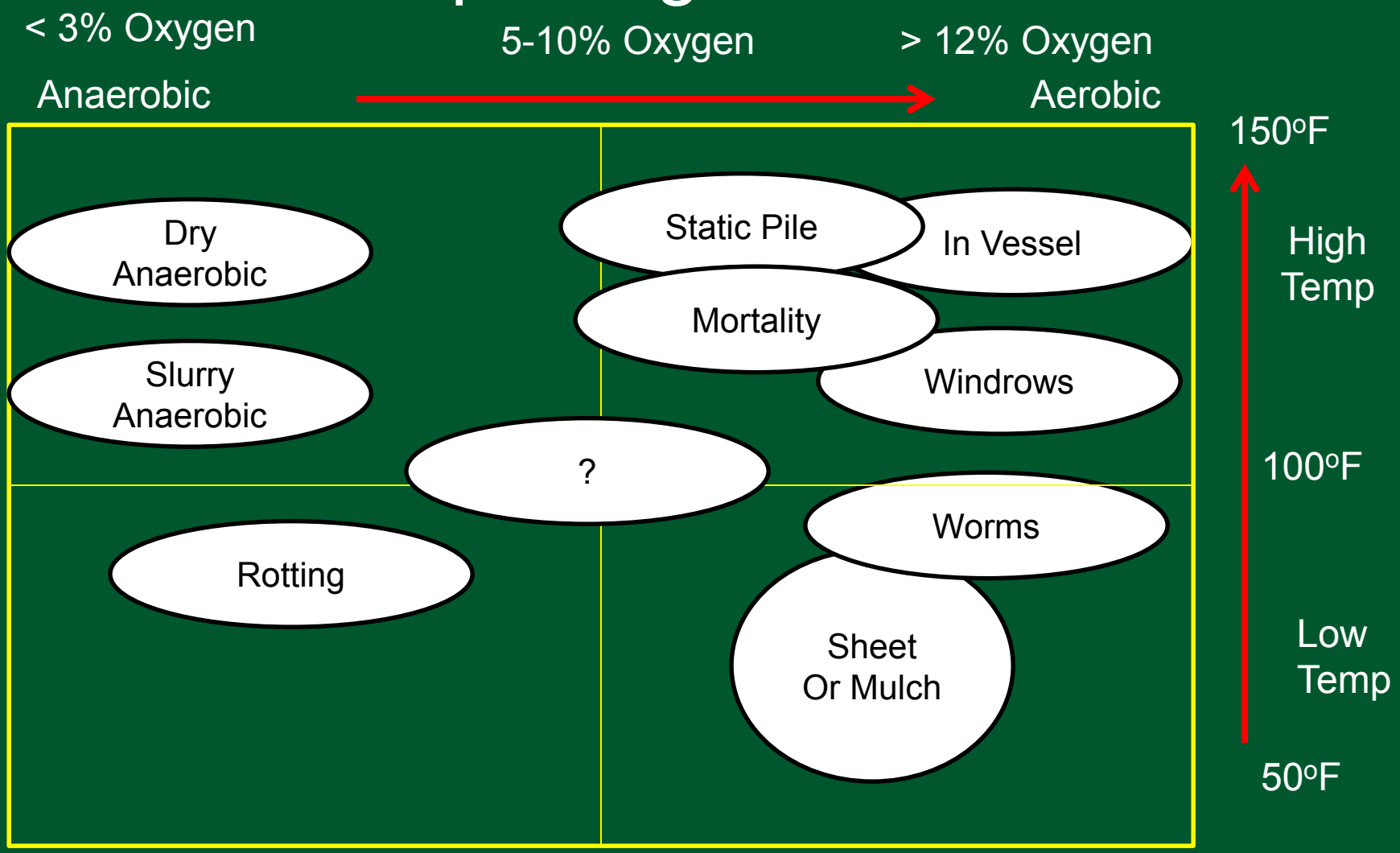
# Calculating C:N Ratio

- Weight or Volume basis?
  - Based on weight
  - Use bulk density to convert volume to weight
- Weight (lbs) x %N = lbs N
- Weight (lbs) x %C = lbs C
- lbs C / lbs N = C:N

# Example Calculation
# 1 brown to 1 green

- 100 lbs of dry alfalfa hay at 15:1
  - %N = 3 so 0.03 x 100 lbs = 3 lbs N
  - %C = C:N x % N = 15 x 3 = 45%
  - Lbs C = 100 x 0.45 = 45 lbs C
- 100 lbs of dry straw at 70:1
  - %N = 0.7 so 0.007 x 100 lbs = 0.7 lbs N
  - %C = C:N x % N = 70 x 0.7 = 49%
  - Lbs C = 100 x 0.49 = 49 lbs C
- Combination
  - Nitrogen: 3 + 0.7 = 3.7 lbs N
  - Carbon: 45 + 49 = 94 lbs C
  - 94 lb C / 3.7 lb N = 25:1 C:N and will compost well

# Composting Methods




Other Variables: Feedstocks, Amendments, Moisture, Time

# Several Bins in Line

If same bin is used for starting, later bins can be smaller due to shrinkage of material.

# Minimum Pile Size

- Often stated as 3’x3’x3’
- Can be smaller with heat retention and moisture retention
- Is easier to get heat and maintain moisture with larger piles.

# Piles are Easier to Turn Then Bins if Space is Available


Piles Constructed May 30, 2009
Picture Taken June 25, 2009

# But “windrows” are easier to turn then piles

# Turning Methods

# Turning Methods

# Turning Methods

# Turning Methods

# Turning Methods

# Turning Methods

# Turning Methods

# Finished Compost Pile After “Rolling” or Turning From the Side With a Loader

# Lift and Roll from the Side

# Bury Top Layer with Inside Material

# Leaves and Grass – Larger Scale

# Building Pile with Spreader

# “Windrow” in the Shade

# Windrows For Large Scale

# Large Bucket Can Reduce Time but Increases Space Required

# PTO Turner – Raised and Lowered with Hydraulics

# Aeration and Physical Breakdown

# Angle of blades creates windrow

# Red Worms – Compost Worms

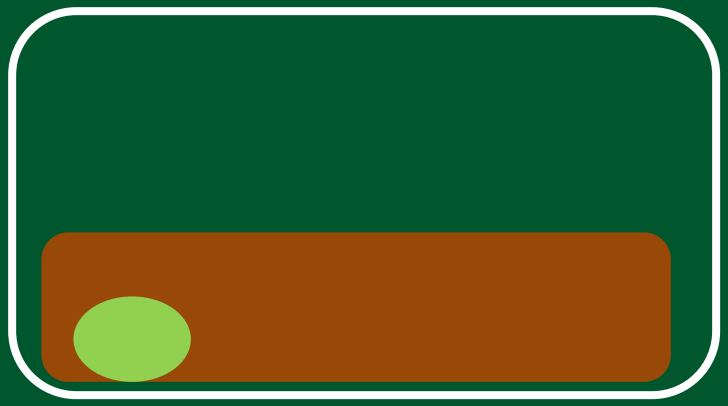
# Bin Composting – Home Scale


Mary Appelhof presenting at a workshop at a conference in Michigan I attended in the 1990's.

# Bin Bedding and Feed System

## Simple and Low Cost;  Works well

Start with large quantity of Bedding and gradually add Feed over time.



Bedding absorbs moisture; Feed decomposed by bacteria and fungi and is consumed by worms.

Feed: kitchen vegetable and fruit scraps, flour, corn meal, hay, grass clippings;  green materials or higher nitrogen material as used in hot composting.

Bedding:  Newspaper, office paper, cardboard, leaves, straw; a “brown” or high carbon material as used in hot composting.

# Flow Through System

https://sonomavalleywormfarm.files.wordpress.com/2013/01/two-long-worm-beds.jpg?w=710


Website: “40’ composter will produce 25 cubic yards per year.”

# Worms active near surface of horse manure January 25, 2016

# Red Worms and Low Temperature

# MSU Worm House – Started 2010

# Bury Material in Trenches or Place on Surface?

# Big “Bin” System - $100 of lumber

# “Wedge” System – Surface Feeding

# Precomposting Prior to Worms

## 80-100°F in January

# Pile Maintained Some Heat Through Winter

# Precomposting Pros and Cons

# Outdoor Pile – January 8, 2016


# Outdoor Pile – Jan 25, 2016
# Horse Manure

# Fresh Manure on Side (Wedge)

# Worm Worked Horse Manure Wedge

November 2, 2016

# Harvesting

# Wedge Reset

# Finished Material Covered for Winter

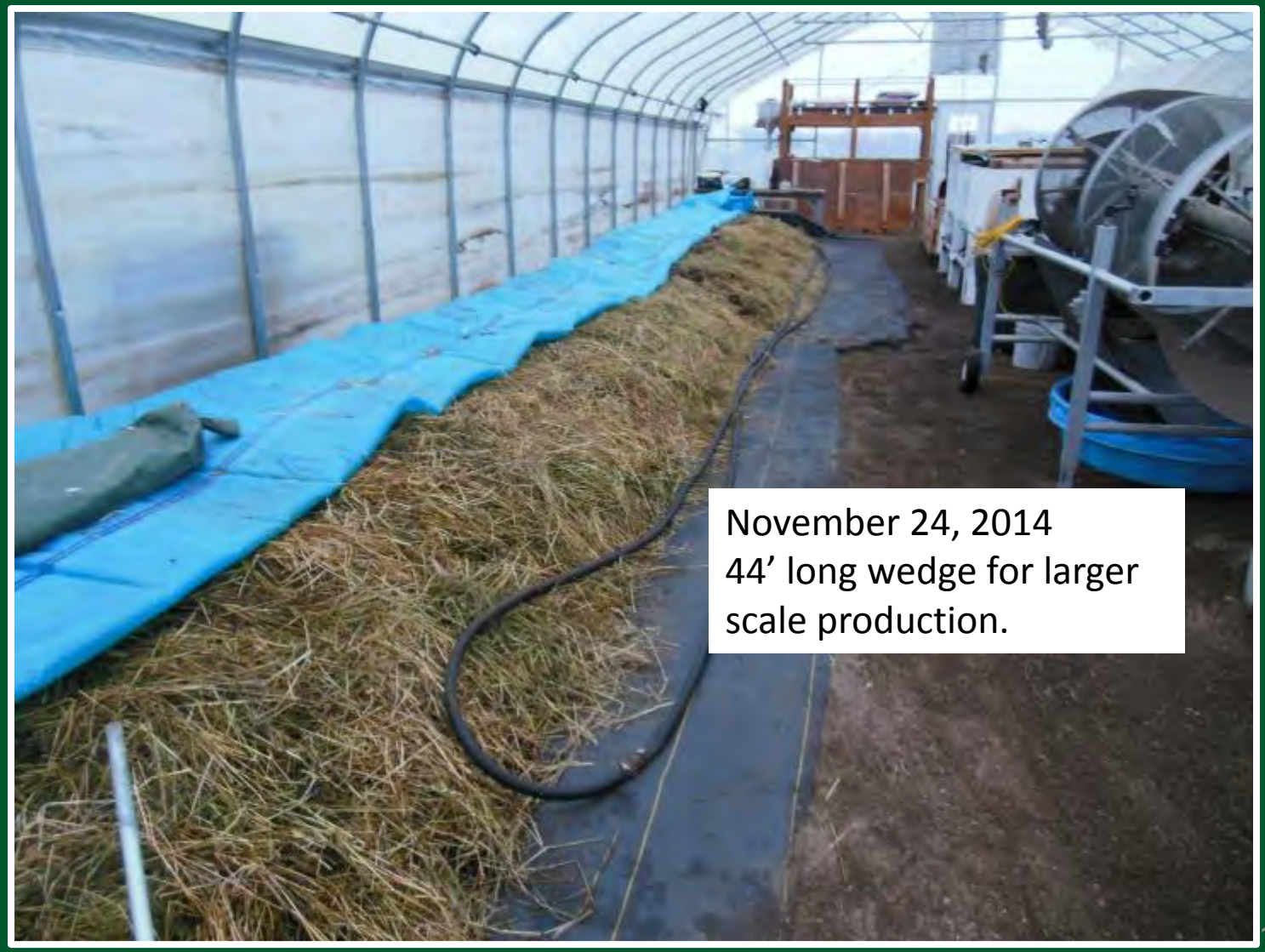

A wedge system can be managed to have many of the benefits of a low cost flow through.
October 2014
Leading edge of wedge with feeding and active worms.
Finished vermicompost ready for screening.

November 24, 2014

Finished compost was removed. Worms moved back to the start by forking partially worm composted materials to begin the process again.

Composting and worm extraction continue. Will be ready for harvest in future weeks.

# “Wedge” System



# Harvest Summer 2015

# Ready to Start Wedge Over

# Worms Moved for Wedge Restart

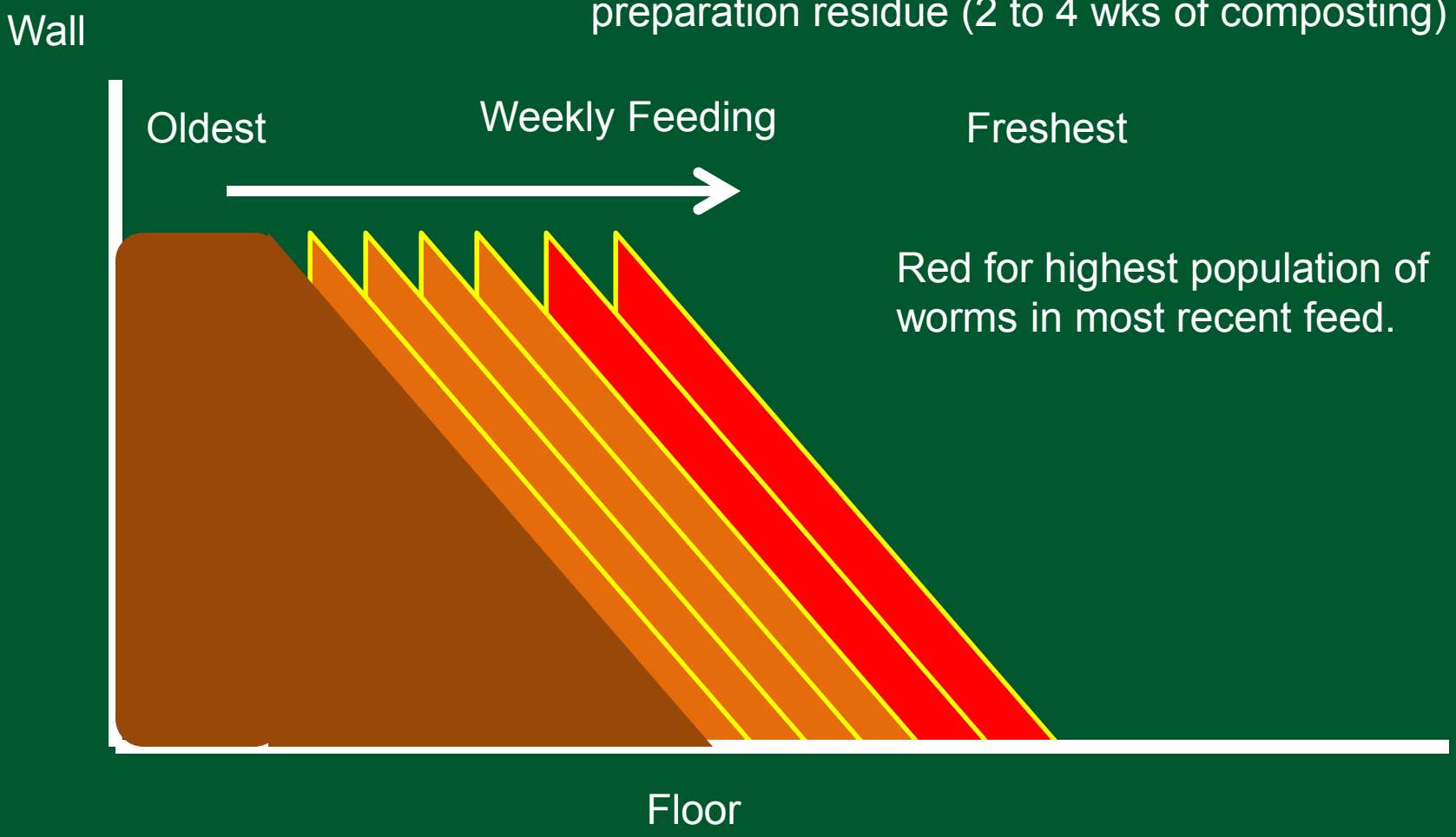
# Wedge Reset – July 2015

# Windrow Wedge with Hay Mulch

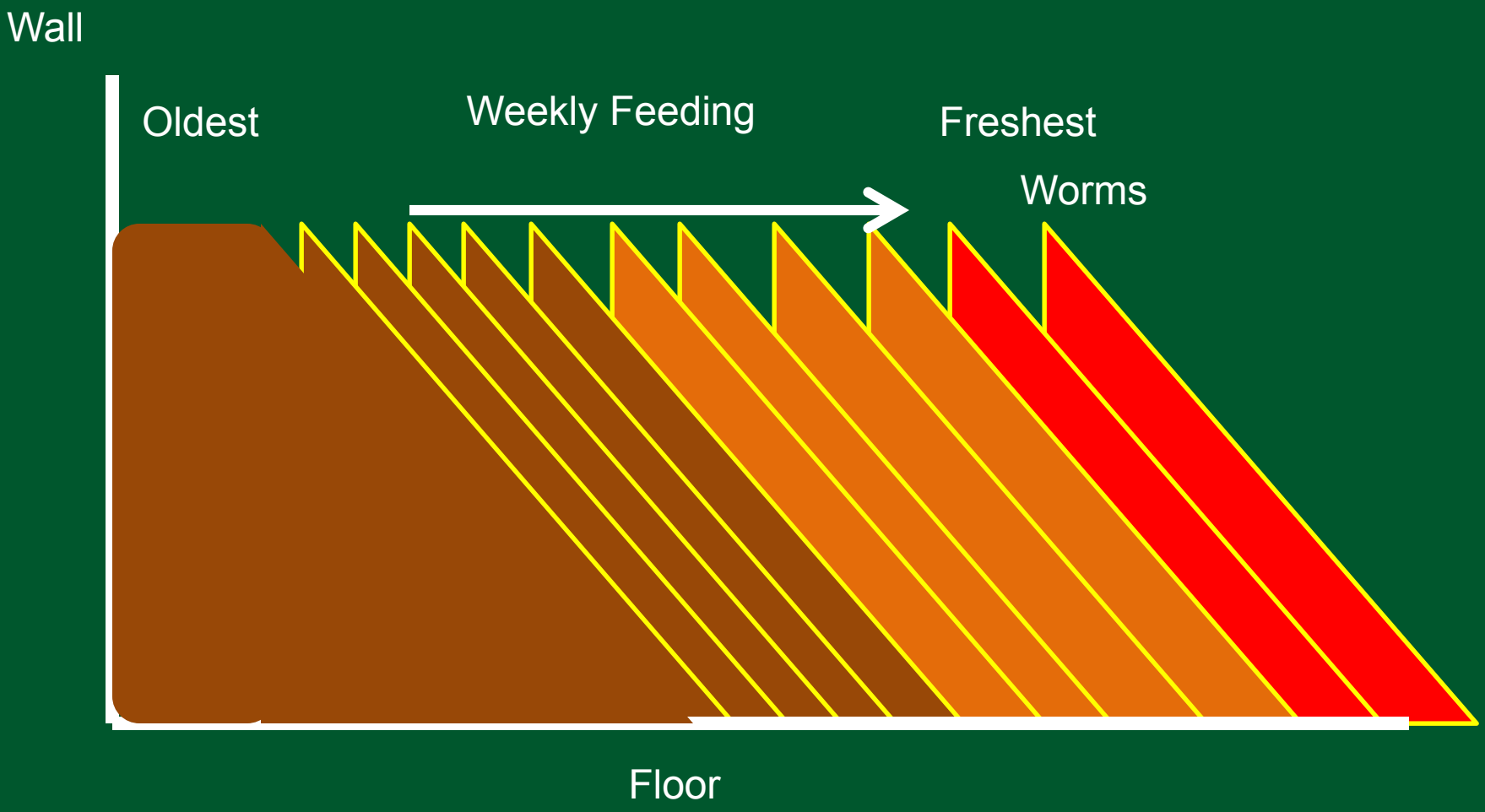
## December 22, 2016 (~ 60°F)

# Wedge System

2” to 6” of precomposted leaves and kitchen preparation residue (2 to 4 wks of composting)

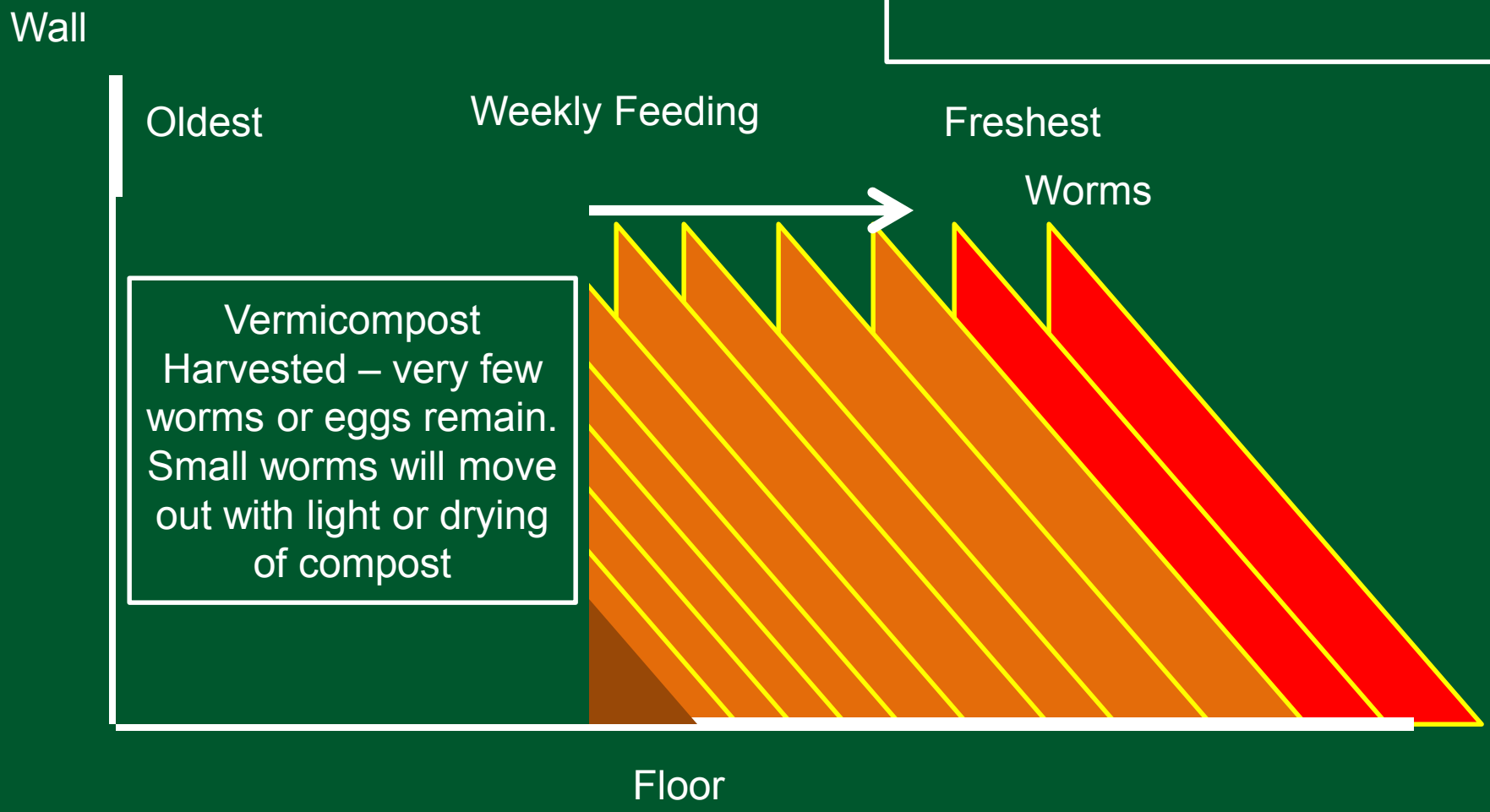


# Wedge System Feeding

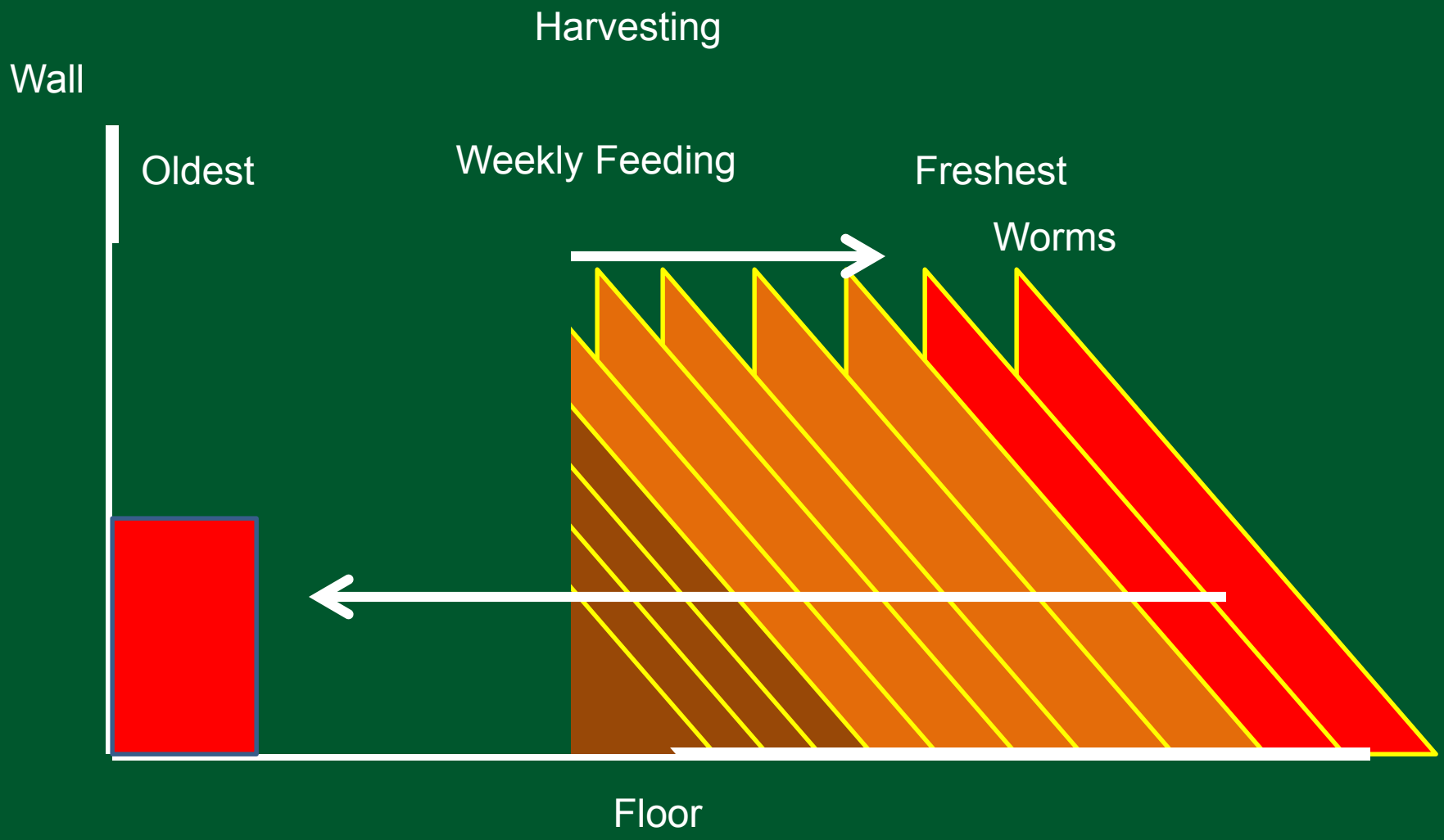


# Wedge System Harvest

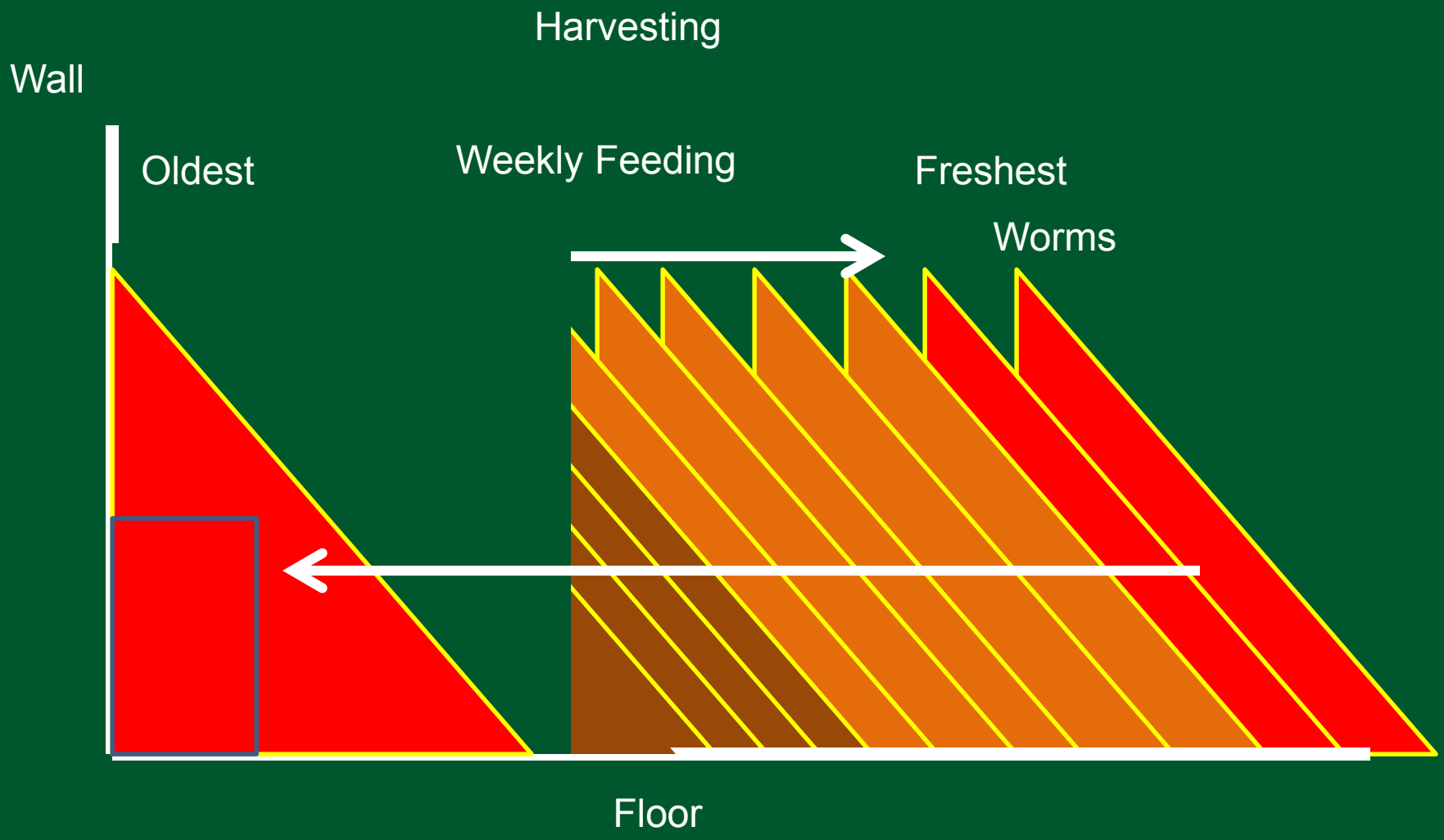
Harvested material has at least 2 months active vermicomposting and 4 to 8 months of vermicomposting total.



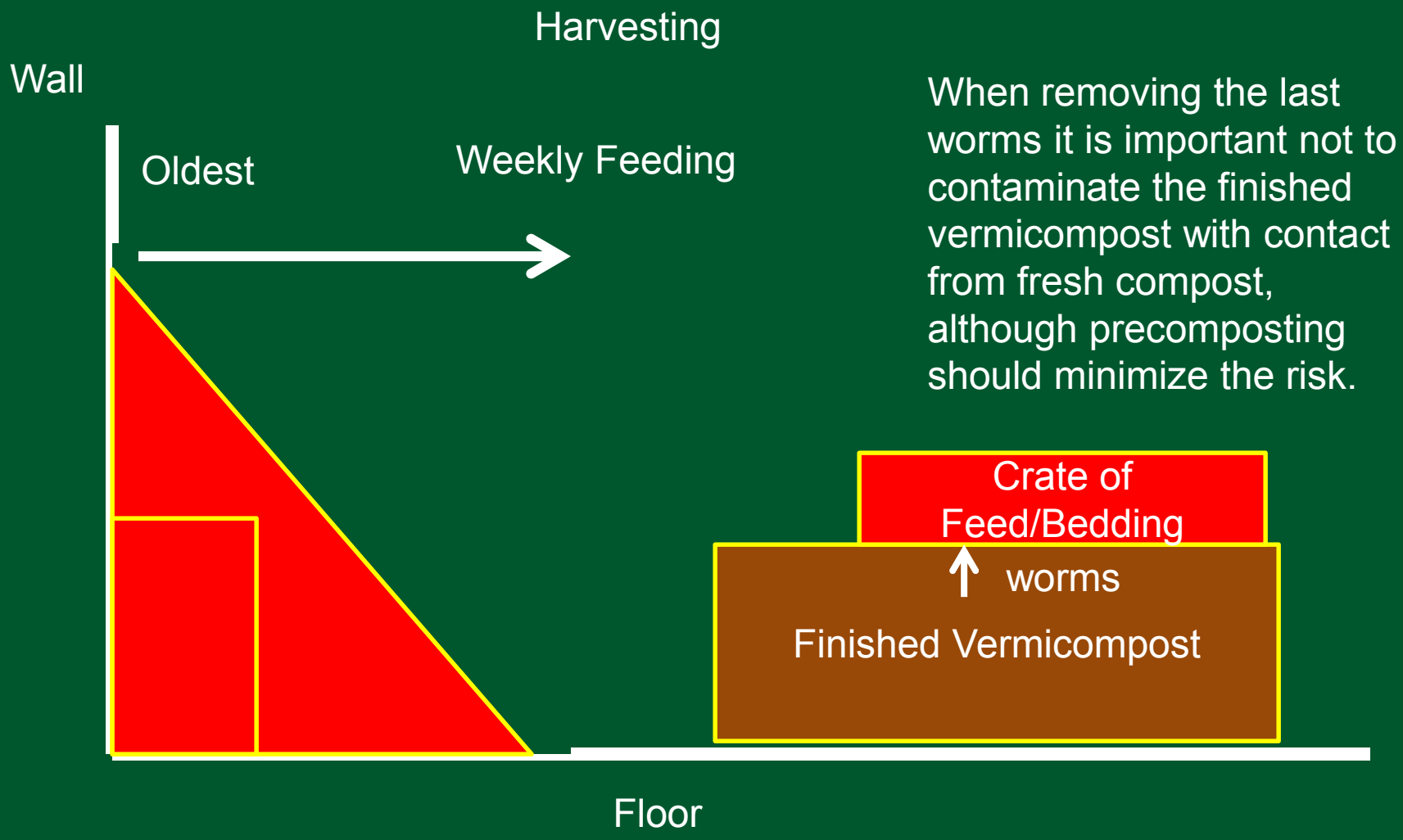
# Wedge System Reset



# Wedge System Reset



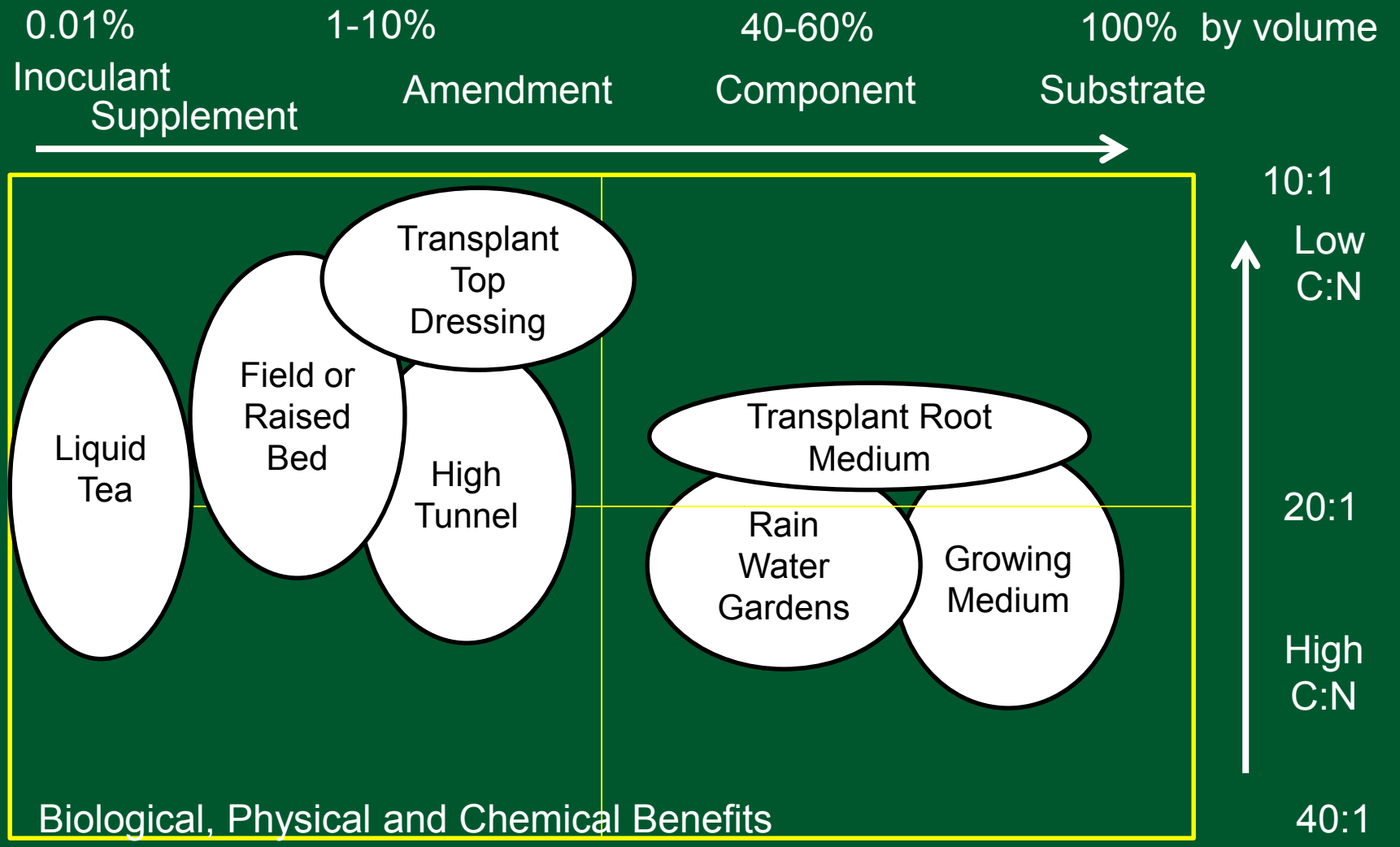
# Wedge System Reset




When removing the last worms it is important not to contaminate the finished vermicompost with contact from fresh compost, although precomposting should minimize the risk.

# Bulk Storage of Finished Product

# Uses and Applications




1 ton/acre compost is approximately 0.25% by volume AFS or 0.1% by weight.
4 ton/acre is approximately 1% by volume and 10 ton/acre is 1% by weight.

# High Tunnels and Hoophouses

Passive Solar Greenhouses (PSGH), also known as high tunnels or hoophouses are used for year round crop production – extended cropping for warm season vegetables and winter harvest of cool season vegetables.

# High Tunnel Site Preparation

# High Tunnel and Garden Application

# Field Application with Manure Spreader

For lower rates of application, lime or fertilizer application equipment may be more practical.

# Distribution is influenced by the weight and moisture content of the compost.


Rolling belt moves compost.

Spinning disc throws compost.

Gate adjusts rate.

# How to spread this on 10 acres?

# Compost Application

# Compostponics: August 8, 2012

# Excellent tomato and cucumber yield 3rd year growing in compost

# Romaine Lettuce in Compost on Roof

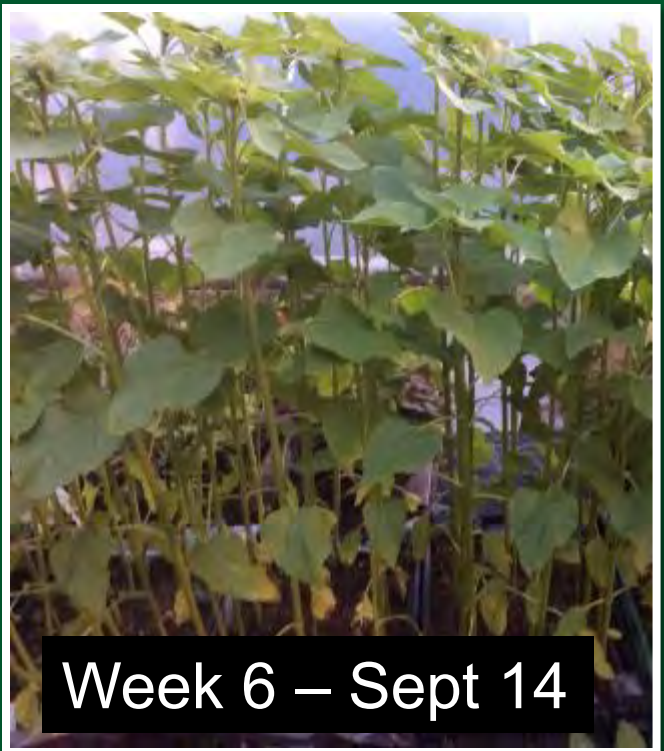

Week 1 – August 8


Week 2 – August 16


Week 3 – August 23


Week 4 – August 31


Week 5 – Sept 6


Week 6 – Sept 14


Week 7 – Sept 21


Week 8 – October 2

# Transplants

# Formulating Transplant Media

- Start with pH and EC analysis of compost
- Usually have to lower pH and soluble salts
- Peat will lower pH
- Coconut Coir will have little effect on pH
- Perlite and vermiculite will lower salts and often increase aeration and drainage while reducing bulk density (weight)

Bioassay

tomato

kale

cucumber

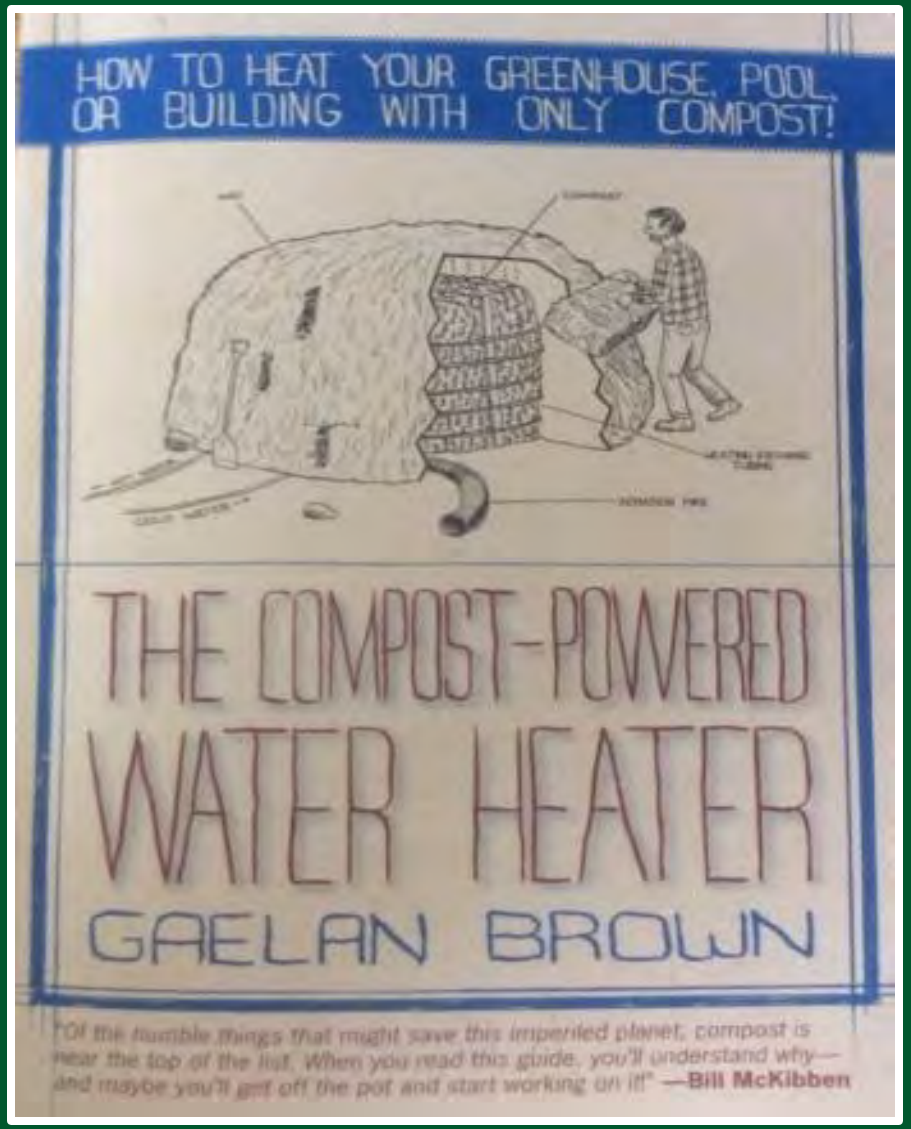
12 media

# Compost Tea

# Large Scale Compost Tea

# Compost Tea Application

# What about compost for heating water?




Recently published recommended book that includes good ideas and pictures with details.

# Compost Production and Use

www.hrt.msu.edu/john-biernbaum/pg4