Curriculum for Farm Interns: Education Modules

PDFs of presentations developed as part of an NCR-SARE Farmer Rancher grant,
FNC12-896 "An Internship Curriculum for Food Farmers in the North Central Region."
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Niles, MI 49120
Contact bertrandfarminc@gmail.com for more information.

Topics: Page

SOIL SCIENCE

TERMS

Fauna- animal life
Biology- the science of life and living matter

Learning Objectives

- Understand how soils form
- Understand soil characteristics and how they effect crop growth
- Learn why and how to take soil samples, what to test for and what to do with the results
- Learn how to manage for healthy soil ecosystems, increased fertility, and sustainable crop production

How is soil formed?

The formation of soil happens over a very long period of time. It can take 1000 years or more. Soil is formed from the weathering of rocks and minerals. The surface rocks break down into smaller pieces through a process of weathering and is then mixed with moss and organic matter. Over time this creates a thin layer of soil. Plants help the development of the soil. How? The plants attract animals, and when the animals die, their bodies decay. Decaying matter makes the soil thick and rich. This continues until the soil is fully formed. The soil then supports many different plants

How Soils Form

Time
Parent Material
Biotic factors
Topography
Climate

Photo credit http://www.eoearth.org/article/Soil_forming_factors

Soil Forming Factors

Weathering is the breakdown of rock into smaller and smaller pieces. Two types of weathering are recognized.

- **Mechanical breakdown** is due to physical factors i.e. temperature, freezing and thawing patterns
- **Chemical breakdown** results from chemical reactions i.e. gypsum and limestone dissolve in water.

Five Factors that affect Weathering and How Soils are Formed

- **Time-** How long the soil has been forming
- **Parent Material-** rock, alluvium
- **Biotic factors-** plants, animals, microorganisms
- **Topography-** slop position, aspect shape and amount
- **Climate-** temperature, moisture, seasonal distribution

See Video on these factors http://youtu.be/bTzslvAD1Es

Soil Toposequence: Moving from the ridge top to valley bottom, soil characteristics vary greatly.

The soil forming process is know as Pedogenesis and is a dynamic process that continues to evolve.

Soil Horizons

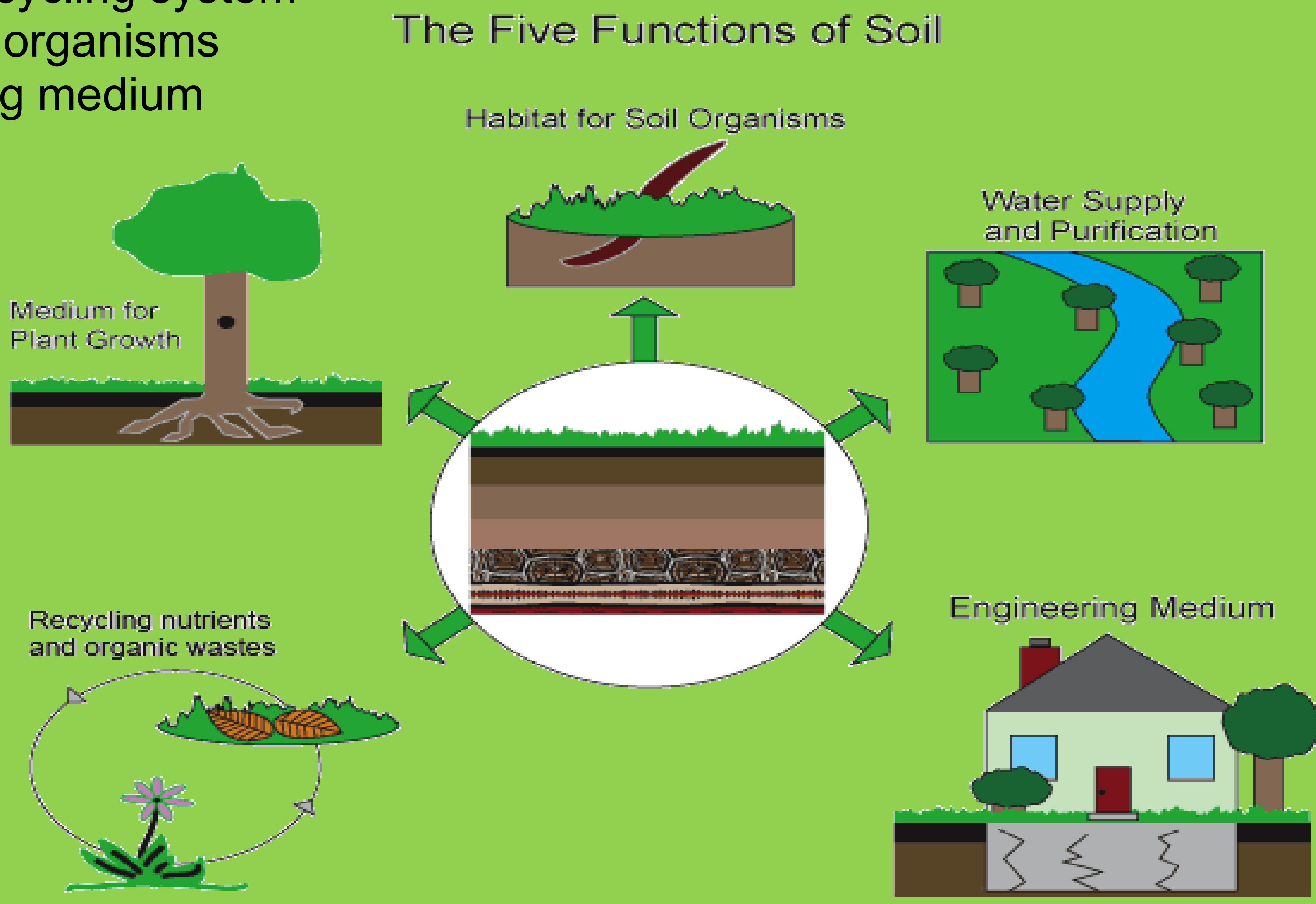
Soil consists of one or more distinct layers called horizons. Horizons are referred to as O,A,E,B,C and R depending on their position and nature.

VIDEO http://www.youtube.com/watch?v=YQhyMsisRD8

SING ABOUT IT: https://www.youtube.com/watch?v=gx2wVHeiTKE

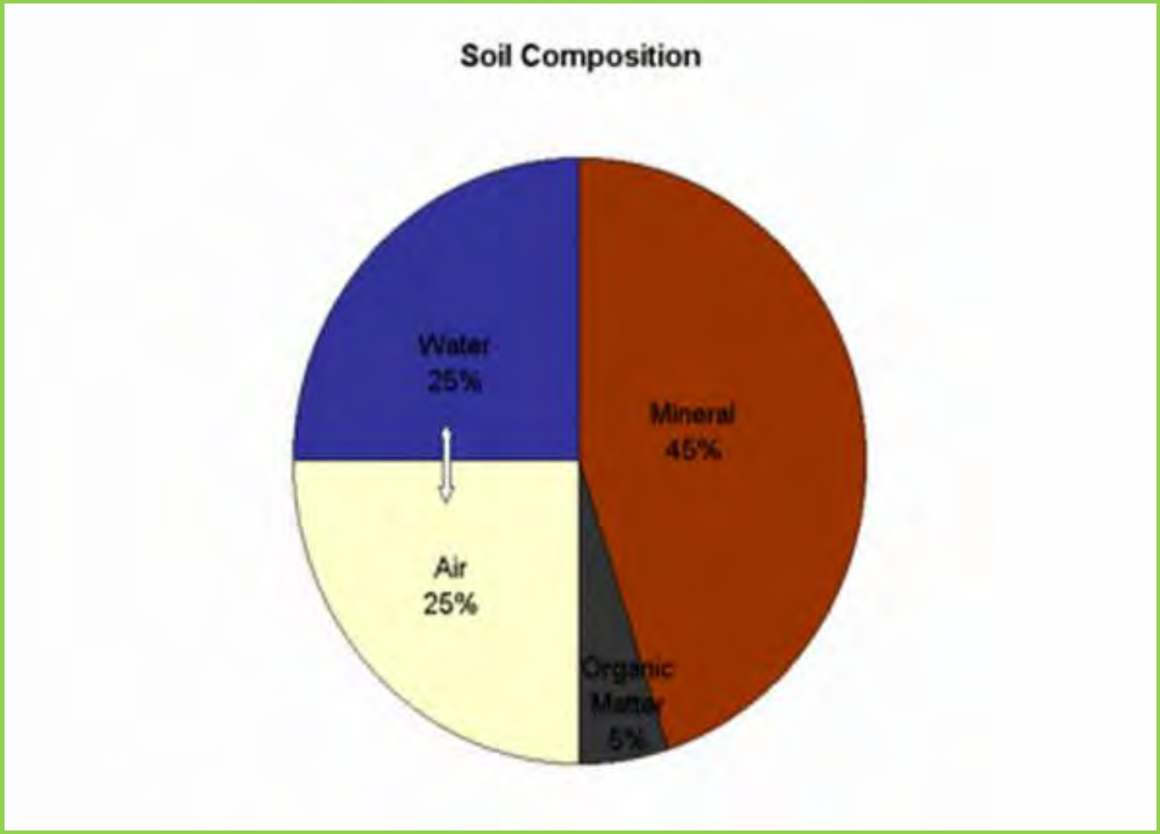
Functions of Soil

1. Support growth of higher plants
2. Primary factor in controlling water
3. Natures recycling system
4. Habitat for organisms
5. Engineering medium



Ideal Soil Composition

Minerals 40 -50%
- Gravel, cobbles, stone
- Sand
- Silt
- Clay



Pore Space 50%
- Air
- Water

Biological 0-10%
- Flora and Fauna
- Live and dead (organic matter)
- Macro and Microscopic

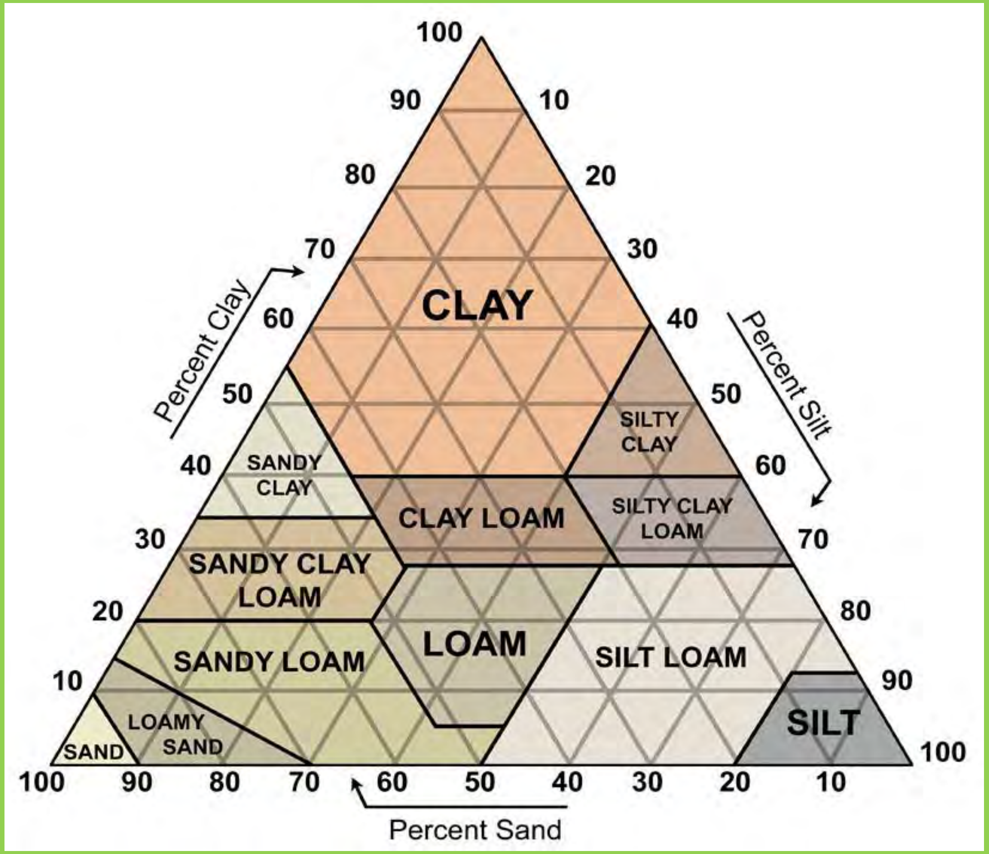
Soil Properties

1. Texture
2. Structure
3. Pores
4. Bulk Density
5. Organic Matter
6. Color
7. Soil Depth
8. Soil Temperature
9. Drainage
10. Odor
11. Permeability
12. Available Water Capacity(AWC)

1. Soil Texture: refers to the mineral part of soil. It tells how much sand, silt or clay is in the soil. Soil texture can be described by the percentage of each as seen in the texture triangle. There are 12 soil texture types.

<u>12 Texture Types</u>

Clay	C
Sandy Clay	SC
Silty Clay	SIC
Clay Loam	CL
Sandy Clay Loam	SCL
Silty Clay Loam	SICL
Sandy Loam	SL
Loam	L
Silt Loam	SIL
Loamy Sand	LS
Sand	S
Silt	SI

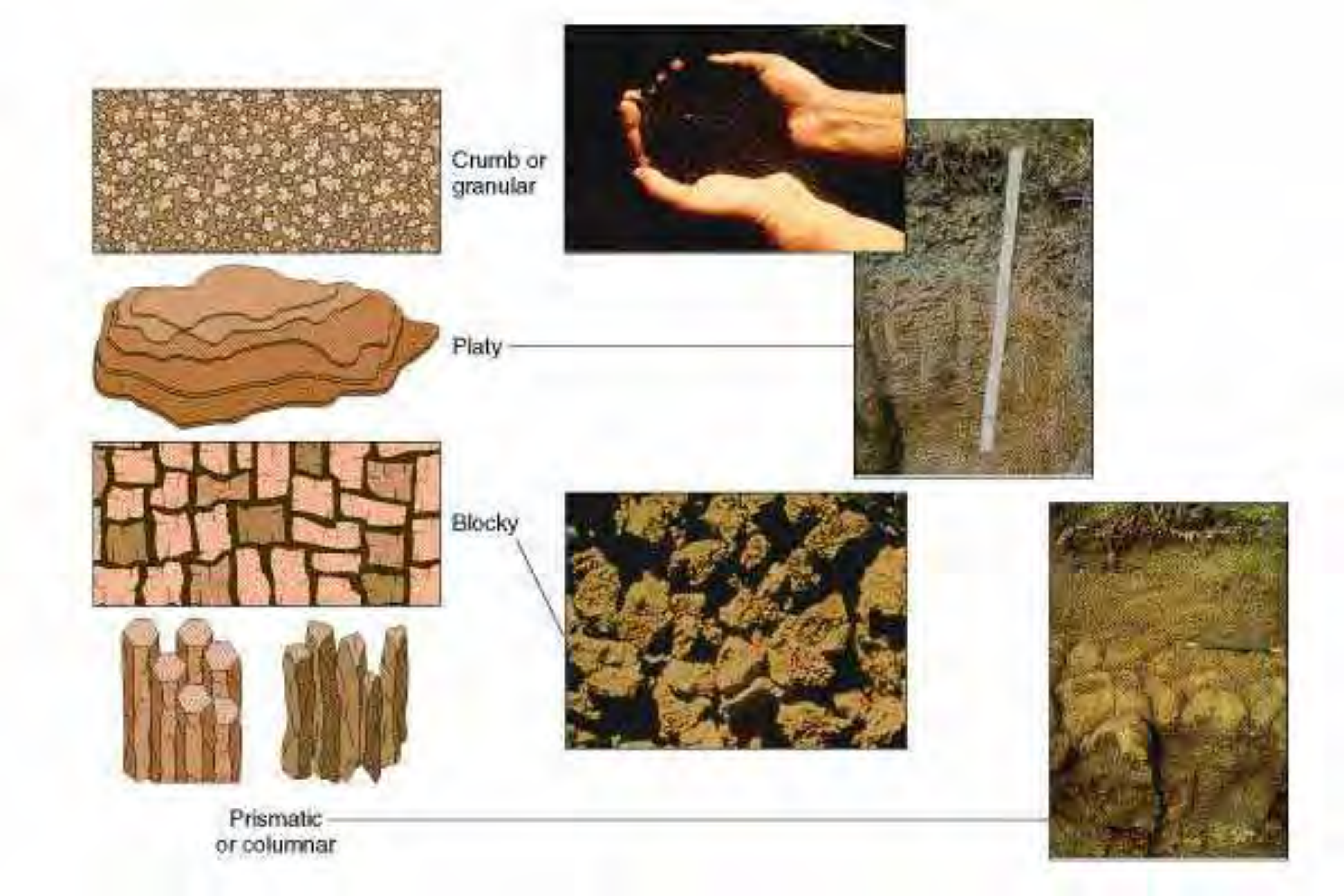


Silt - floury when dry, greasy when wet
Sandy soils- gritty; low water and nutrient holding capacity; droughty
Clay soils- microscopic layers ; high water and nutrient holding capacity, but low permeability; poor tilth.

SING ABOUT IT AGAIN: https://www.youtube.com/watch?v=gx2wVHeiTKE

Soil Properties

2. Structure in soil refers to the arrangement of soil particles and pores into aggregates. Structure affects permeability.



Soil Properties

3. Pores

Pores are the holes or voids between soil particles. They are important because air and water move through and are stored in pores. Air and microbes can not live with out air and are essential to healthy soil.

4. Bulk Density

Bulk Density of a soil is the dry weight of a given volume of soil divided by the volume. It is expressed in grams per cubic centimeter. Soil bulk density values range from .5 - .3 but most are between 0.8 and 1.8. Anything denser than 1.8 is root limiting. Compacted soils have a higher bulk density.

5. Organic Matter

Organic matter consists of dead plant parts and animal parts and microbial waste products in various stages of decomposition. Eventually breaking down to humus.

Organic matter makes up a minor part of soil but has a very significant impact on soul structure, water holding capacity and Cation Exchange Capacity(CEC).

- Organic matter acts like glue to hold soil aggregates together. This will hold upon
- wetting.
- Organic matter helps bind water to soil to keep it from being lost through percolation
- Especially important in sandy soil.
- Humus can have a CEC of 100-300meq/100g(highest CEC in clay is 160meq/100g)

6. Color

Color in soil is measured by the Munsell Color Notation Book. Greens, blues and grays indicate wetness. Bright colors indicate good drainage. Dark colors usually indicate organic matter.

7. Soil Depth

It is important to know the depth of the soil. The depth determines how far the roots can grow and how much water the soil can hold. Depth is measured to the shallowest root limiting layer. Some things that control depth include; bedrock, Natural or tillage hardpans, contrasting textures and water table.

8. Soil Temperature

Soil temperature is important to gardeners as many seeds need a minimum temperature for germination. Soil temperatures are influenced by; air temperature, topography, Plant cover shades the soil, darker colored soils absorb more heat, mulching reduces heat.

9. Drainage

Soil drainage is classified into 7 categories(from the US Department of Agriculture Soil Survey Manual) from Excessively drained to Very poorly drained as a way of expressing frequency and duration of periods in which soil is saturated in excess of field capacity. Excess water in the root zone can kill plants or keep them from taking.

10. Odor

Odor is an indicator of wetness. When soils are waterlogged, bacteria will get their oxygen from sulfur. This will release hydrogen sulfide gas.

11. Permeability

Permeability is the rate at which water moves down through the soil. It is usually measured in inches per hour. Texture and Structure affect permeability. Soil texture not only affects how fast water moves but also affects the pattern. Water will move almost straight down in sandy soil where as it will have more lateral movement in heavy clay soils.

12. Available Water Capacity (AWC)

AWC refers to how much water a soil can hold against the flow of gravity. AWC is Influenced by texture, salts, Organic matter, Compaction, soil depth, and coarse Fragments.

Soil Testing and Assessment

Important elements to test when assessing the quality of your soil:

- minor and trace minerals
- CEC (cation exchange ratio)
- pH
- soil biotic community
- Quantity of Organic Matter

Conventional farming testing focuses on **Mineral Analysis** where as the organic farmer emphasizes **Soil Biotic Communities** and **Organic Matter.**

Soil Testing

https://www.youtube.com/watch?v=8Qx070sHGgo

https://www.youtube.com/watch?v=HHCVIfu1j_U

https://www.youtube.com/watch?v=BLXJR4HrtHc

Important Information gained from Soil Tests

Minerals and Trace Minerals

The presence and quantity of Minerals and Trace minerals in your soil are measured and reported on soil tests . The availability of these minerals to your plants , and ultimately to us, are the basis of nutrition.
Organic farmer s are equally , if not more, concerned about the soils ability to breakdown these minerals into plant soluble form which is accomplished by the microbiology present in the soil.
Minerals are categorized into two groups , major and minor elements. Though needed in much less quantities the minor elements are very important and should always be included in a soil test.

Minerals are nutrition:

http://www.traceminerals.com/research/soilsea

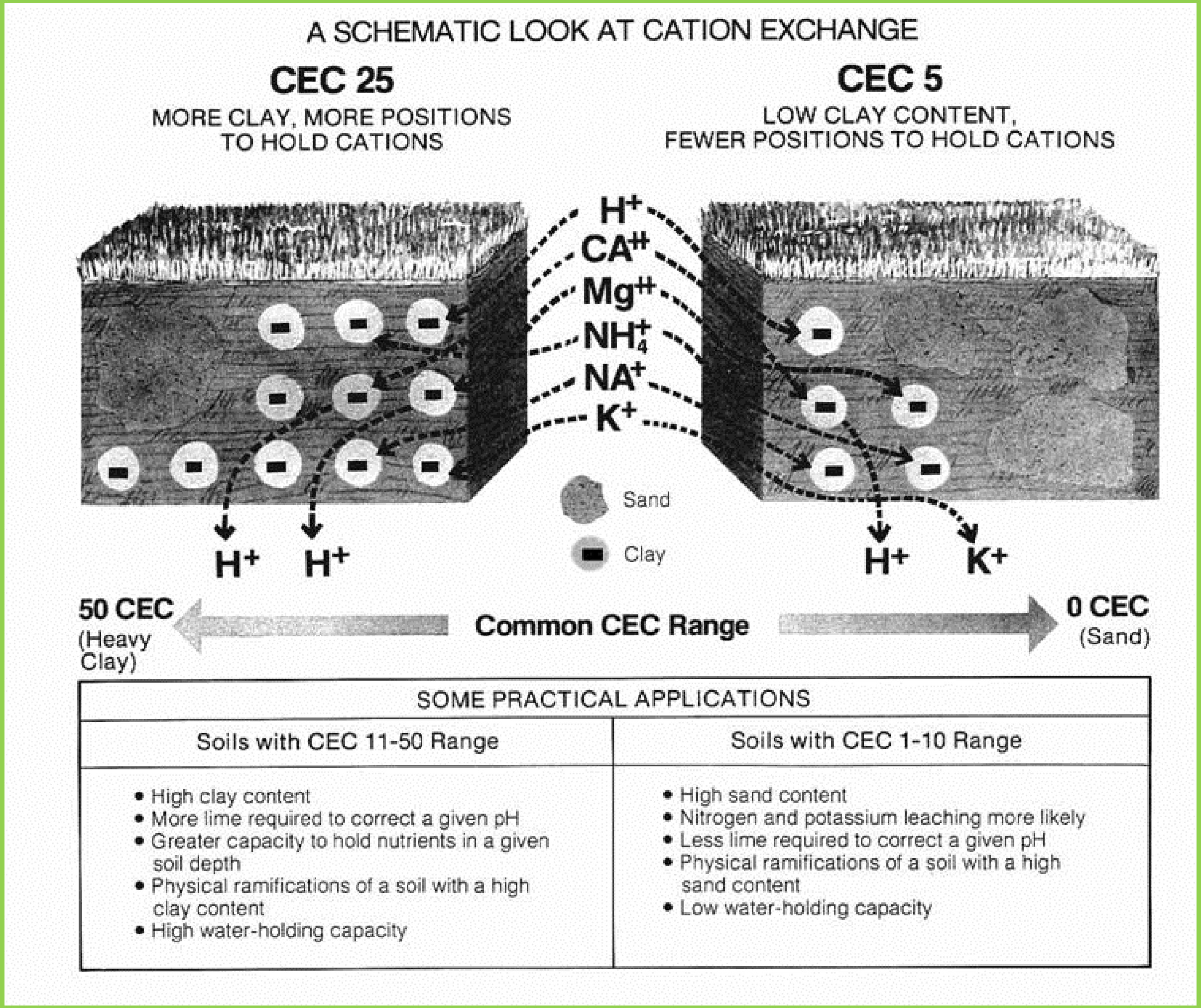
A soil test result:

http://www.soilminerals.com/samplereportI.htm

Important Information gained from Soil Tests

Cation Exchange Capacity

Cation exchange capacity refers to the capacity of negatively charged humus (see slide 13) and clay particles(colliods) to hold cations(Calcium, Magnesium, Potassium- also sodium and amonia).



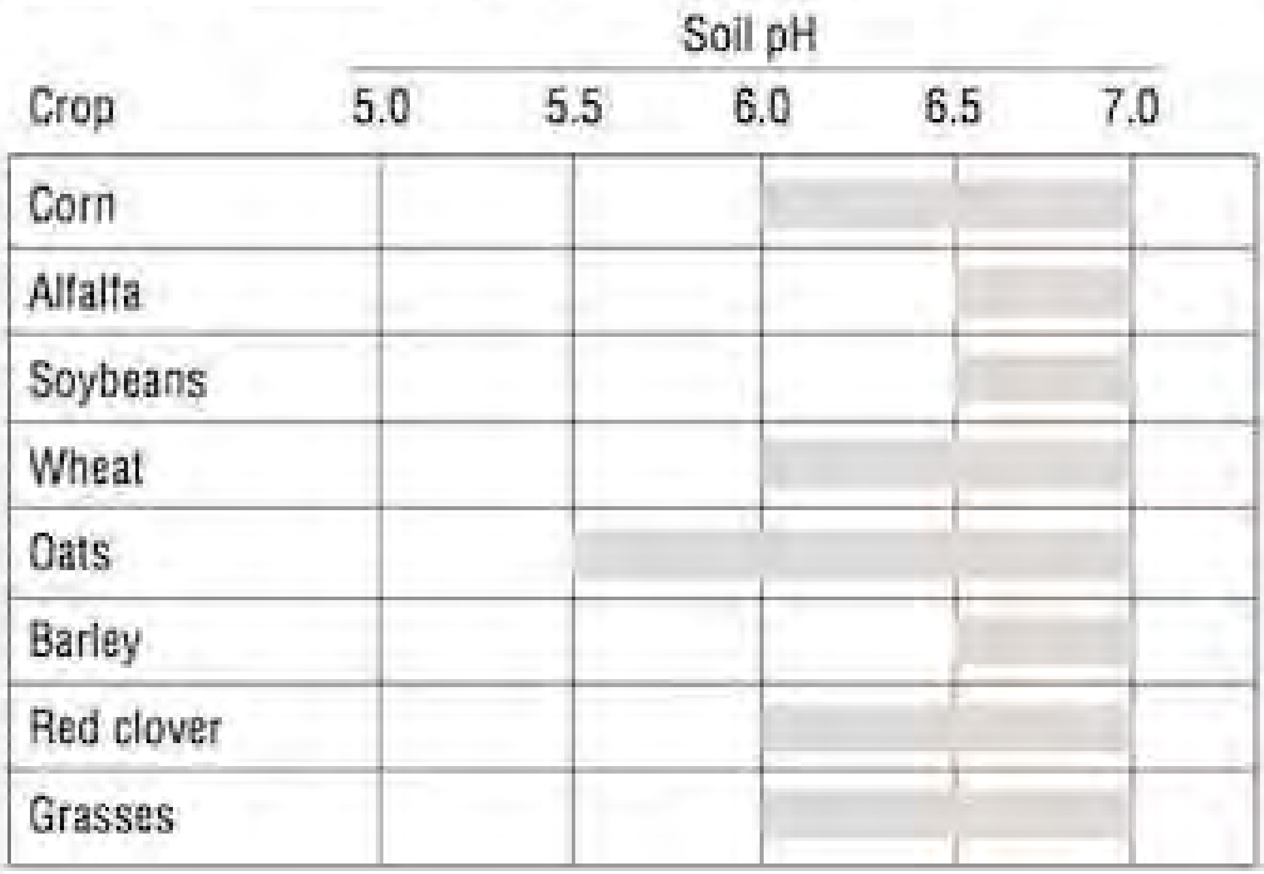
Video Explanation
https://www.youtube.com/watch?v=eHev2Ovrm6M

CEC is measured on soil tests and is important information as to the nutrient holding ability of your soil.

Important Information gained from Soil Tests

Desirable Ph Levels

Figure 1. Favorable pH ranges for common crops.



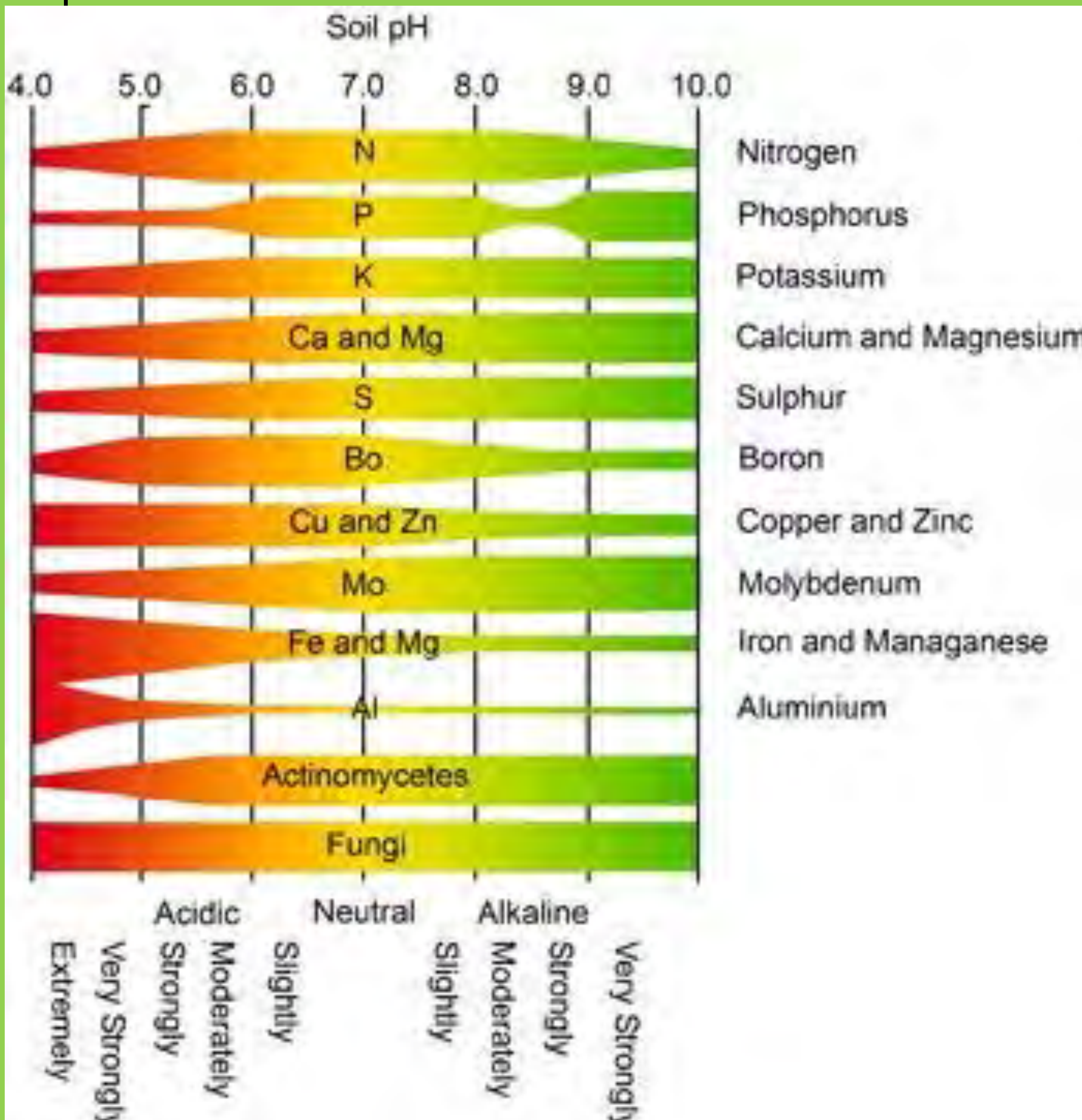
Videos about Ph Level:

http://youtu.be/s_6suv7Nd48

http://youtu.be/7b88FtQC9kc

Important Information gained from Soil Tests

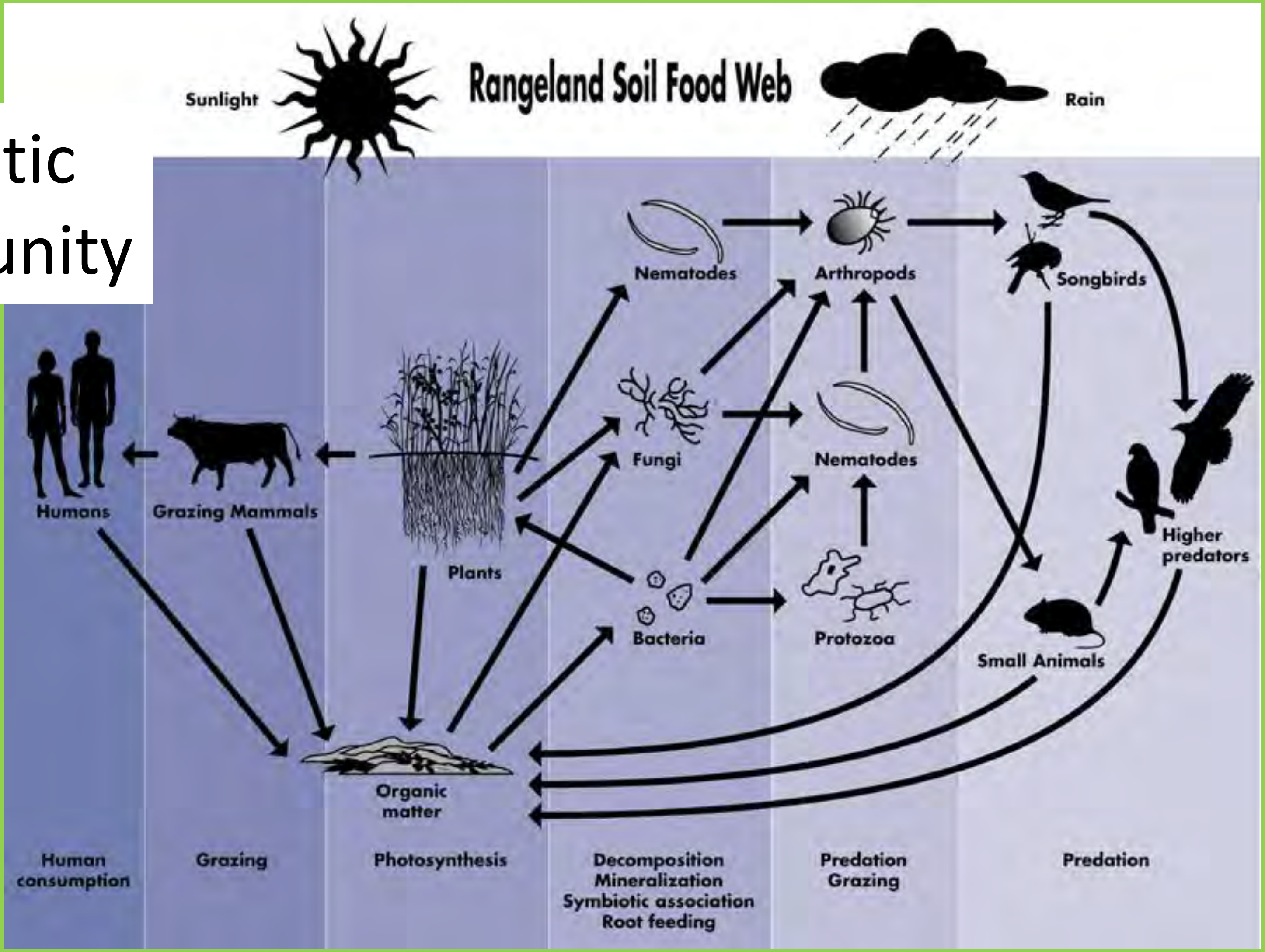
PH and its relation to CEC –(if your bases are balanced, pH will take care of itself)



Soil Ph Video
https://www.youtube.com/watch?v=7b88FtQC9kc

Important Information gained from Soil Tests

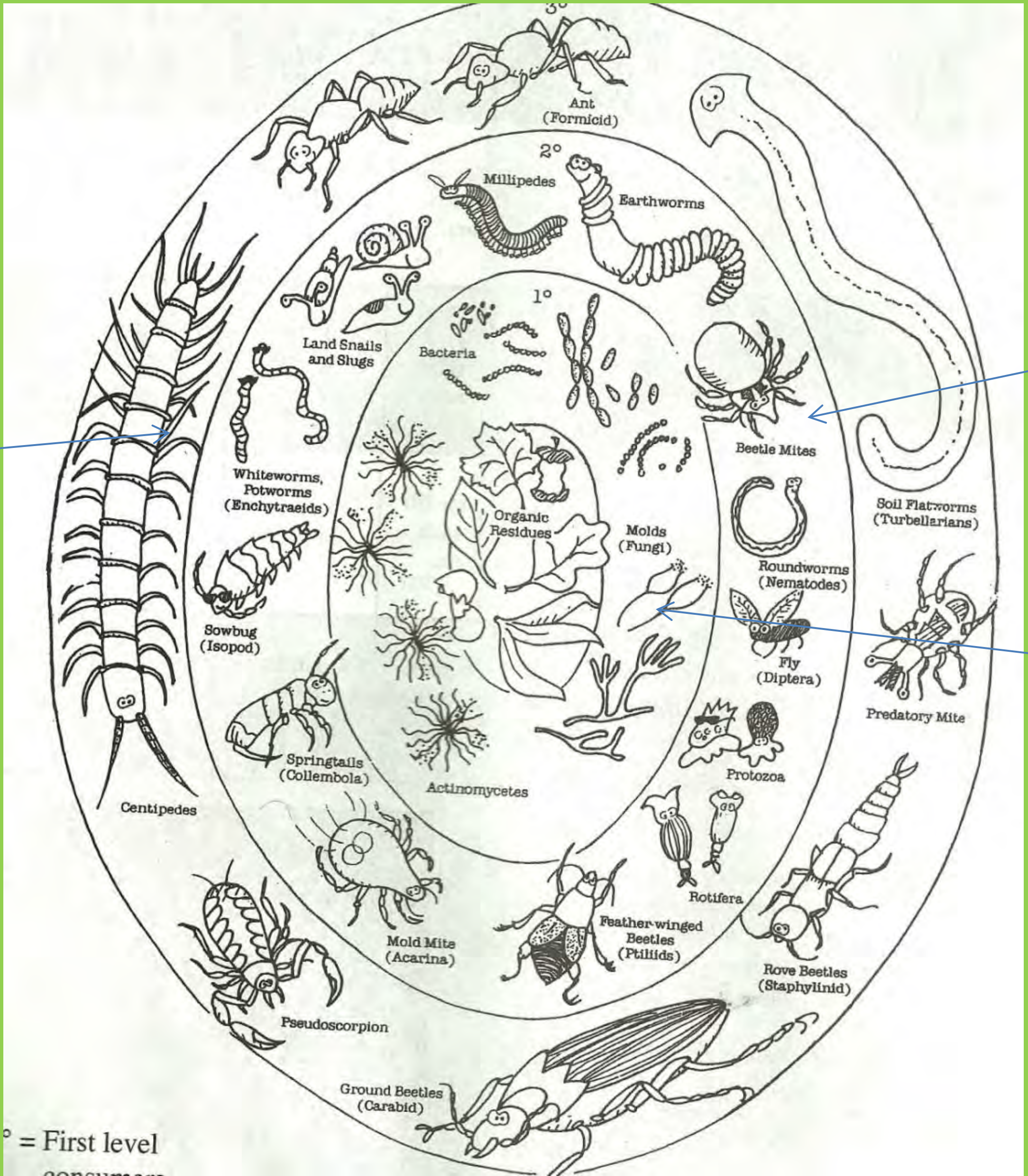
Soil Biotic Community



We know that an acre of soil can support or produce 2000 lbs of beef (cow / calf pair), 5 sheep, and lots of chickens, for example, but we rarely consider the extent of the soil fauna living underground: 1 acre of topsoil contains approximately 900 pounds of earthworms,2,400 pounds of fungi, 1,500 pounds of bacteria, 133 pounds of Protozoa, 890 pounds of arthropods and algae, and small mammals.

The Soil Food Web/Biotic Community

Decomposers 3 levels of consumers (organisms that feed on each other and the organic matter).



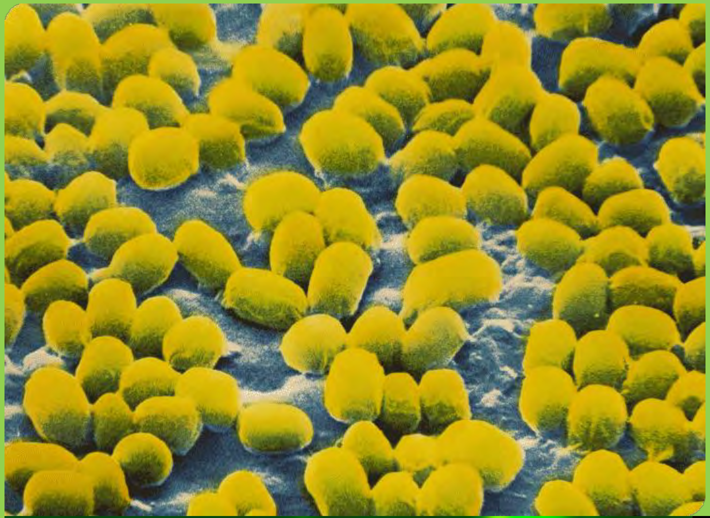
3rd Level
Macro
organisms

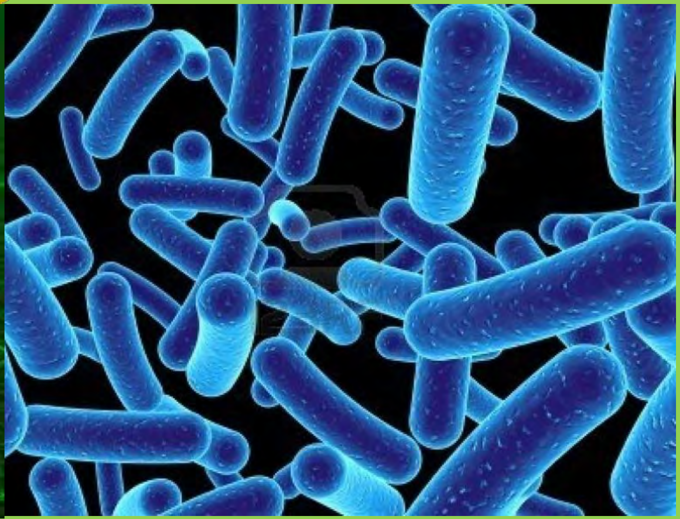
2nd Level
Meso organisms

1st Level
Micro organisms

Micro- Biology in Soil

Bacteria – make plant growth hormones, make nutrients and minerals available to plants, fix atmospheric nitrogen, fight root diseases, and detoxify soils.





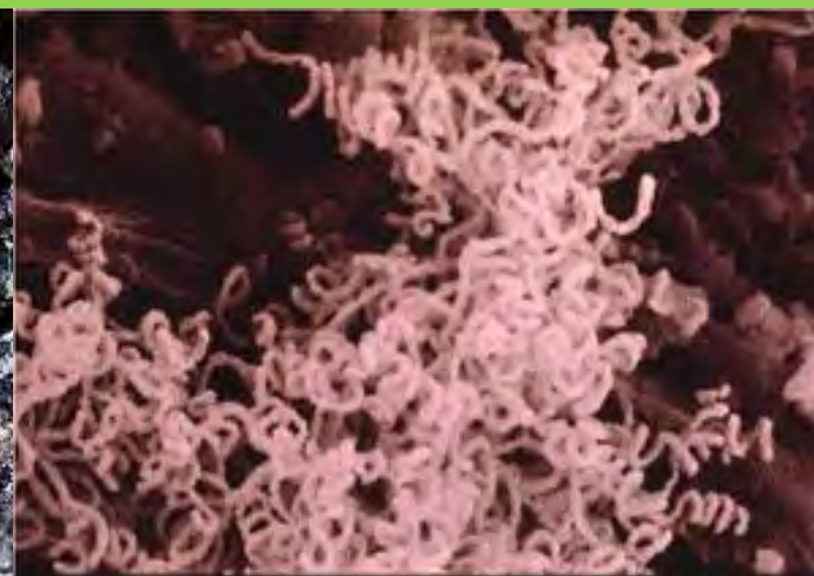
Micro- Biology in Soil

Fungi – break down OM and release nutrients available to plants, produce plant hormones and antibiotics, mycorrhizal associations.

Fungal hyphae in healthy compost

Micro- Biology in Soil

Actinomycetes – threadlike bacteria that look like fungi: decompose OM, produce root disease-fighting antibiotics, and produce a sweet, “earthy” smell.



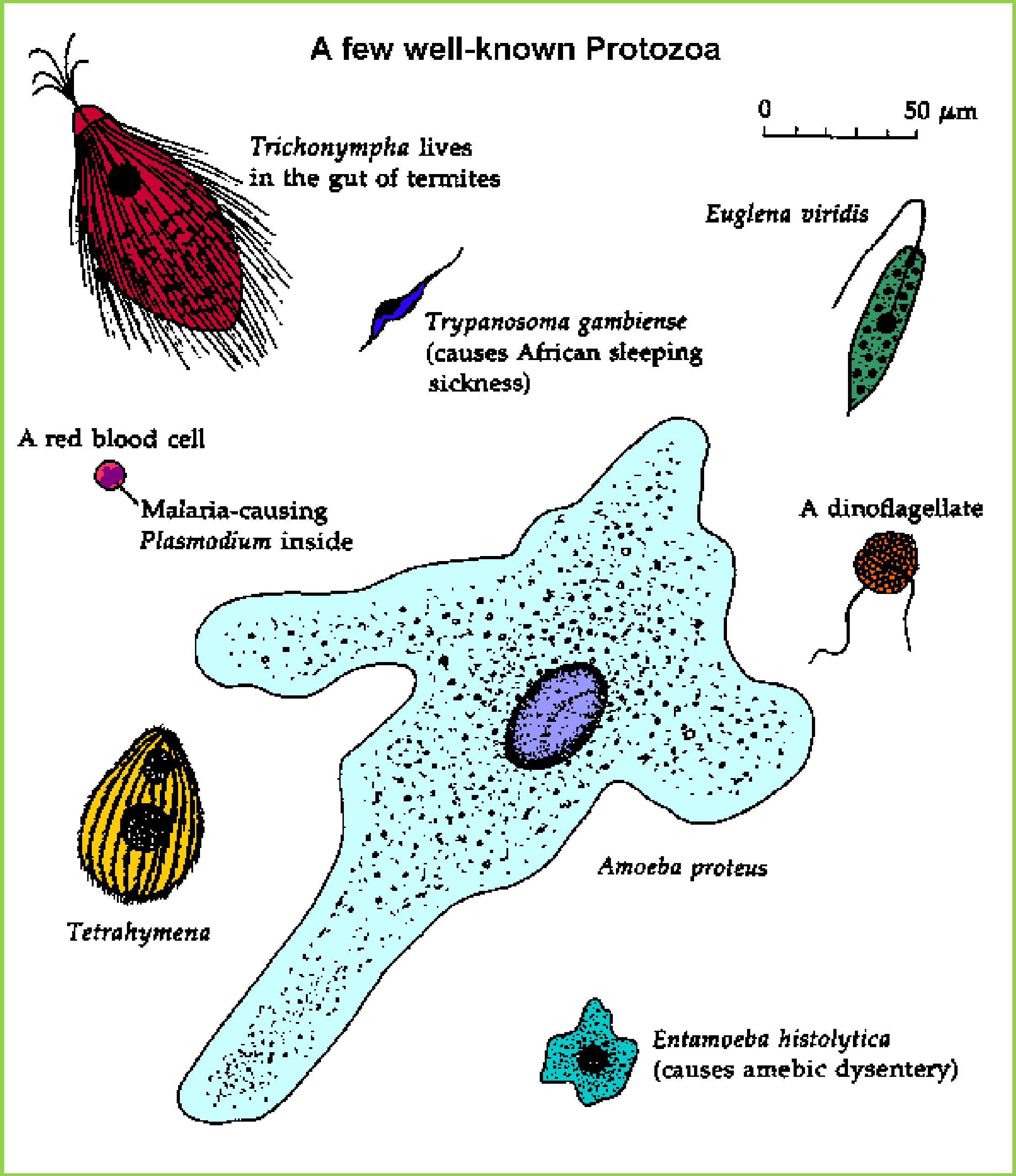
Meso- Fauna

Algae – located in the upper ½ inch of soil .Algae will fix nitrogen and enhance soil structure by producing biologic glues.

Meso- Fauna

Protozoa – free-living organisms

that swim in soil water, eating bacteria and speeding up the nutrient cycle.



Meso- Fauna

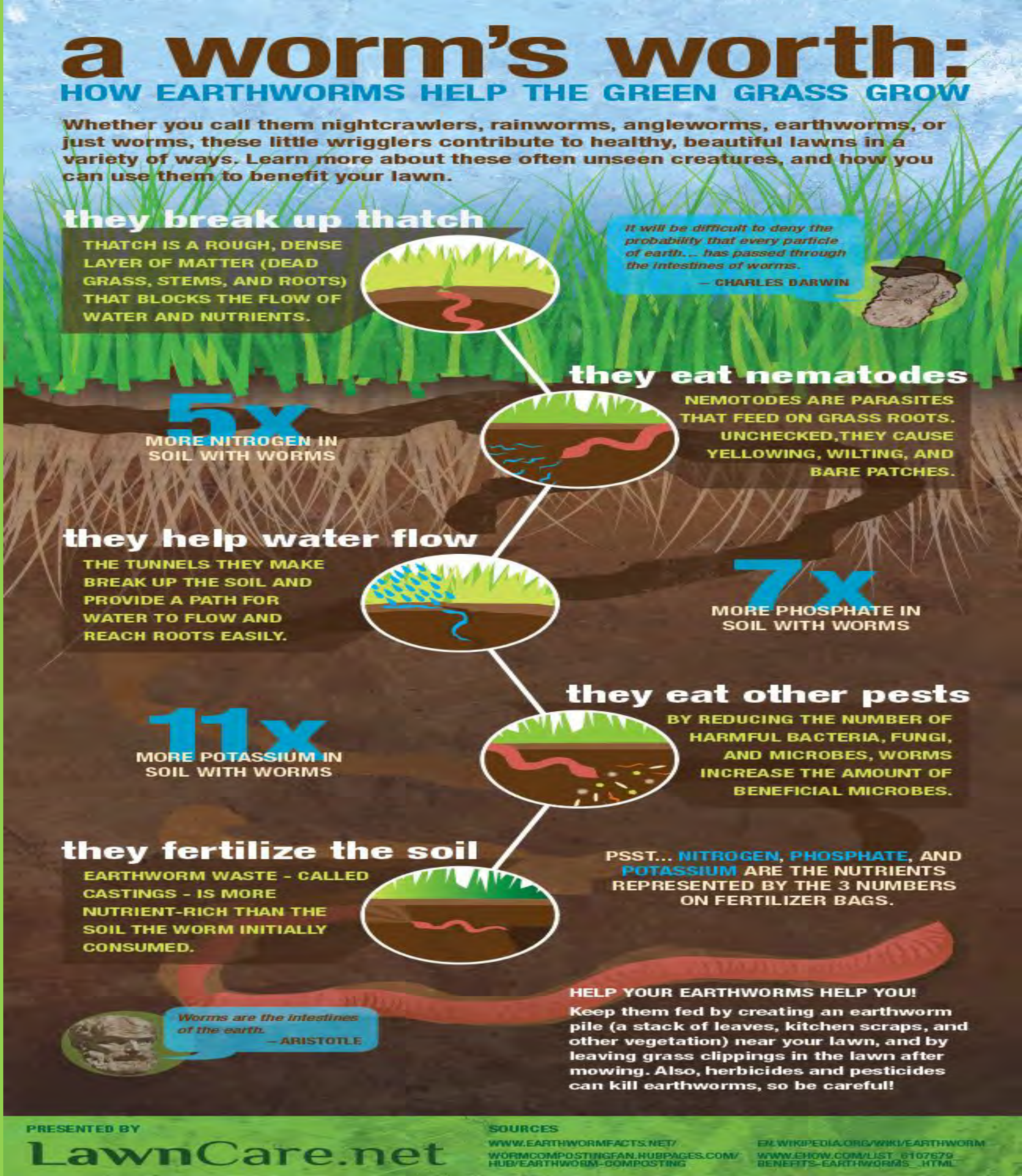
Nematodes – eat decaying plant litter, bacteria, algae, protozoa, and other nematodes – only a few species harmful to plants.

Mega- Fauna

Arthropods – sow bugs, centipedes, slugs, snails, and springtails: primary decomposers

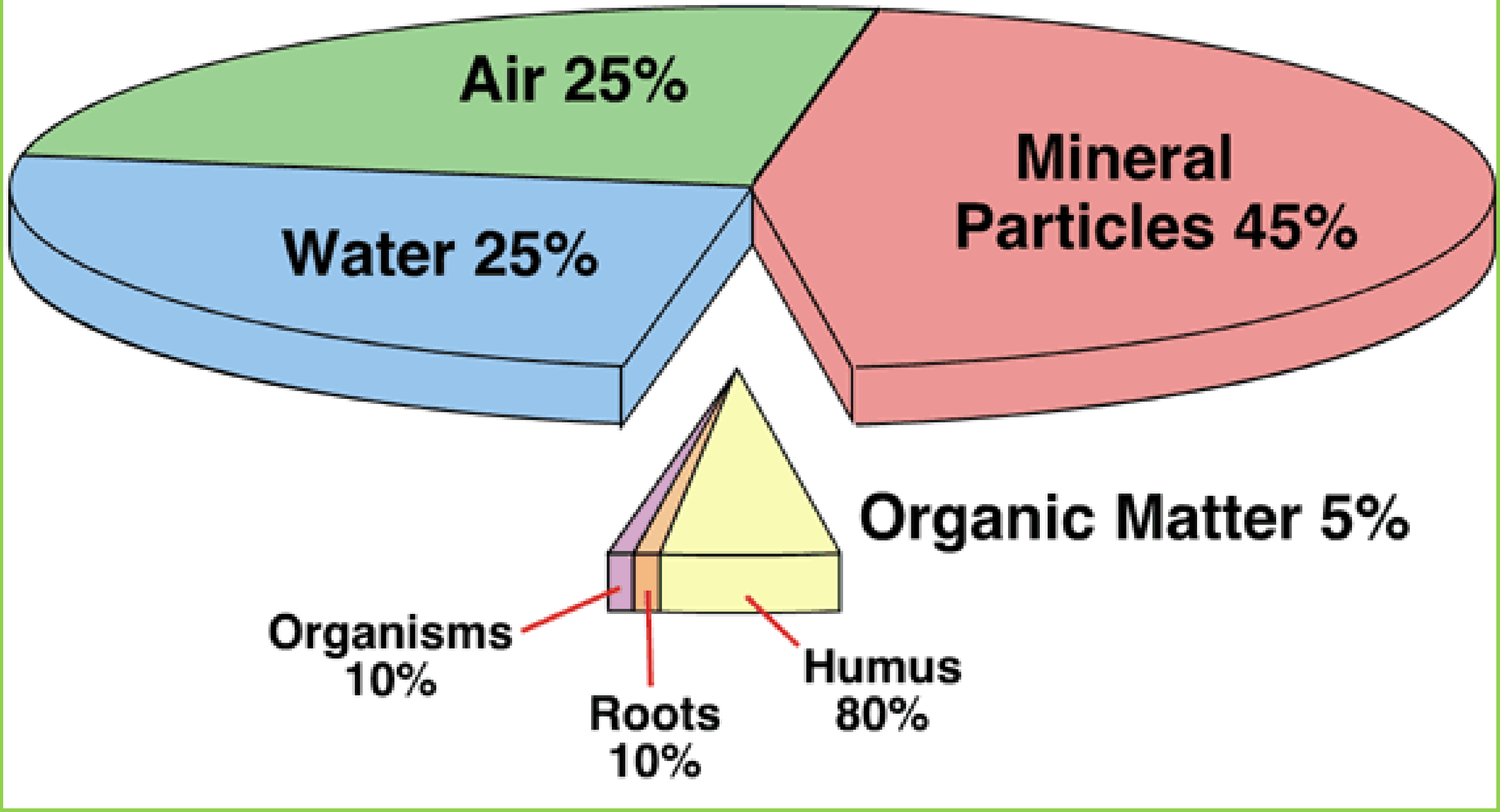
Mega- Fauna

Earthworms – air & water penetration, high-nutrient castings, secretion of plant growth stimulant, natural soil tiller.



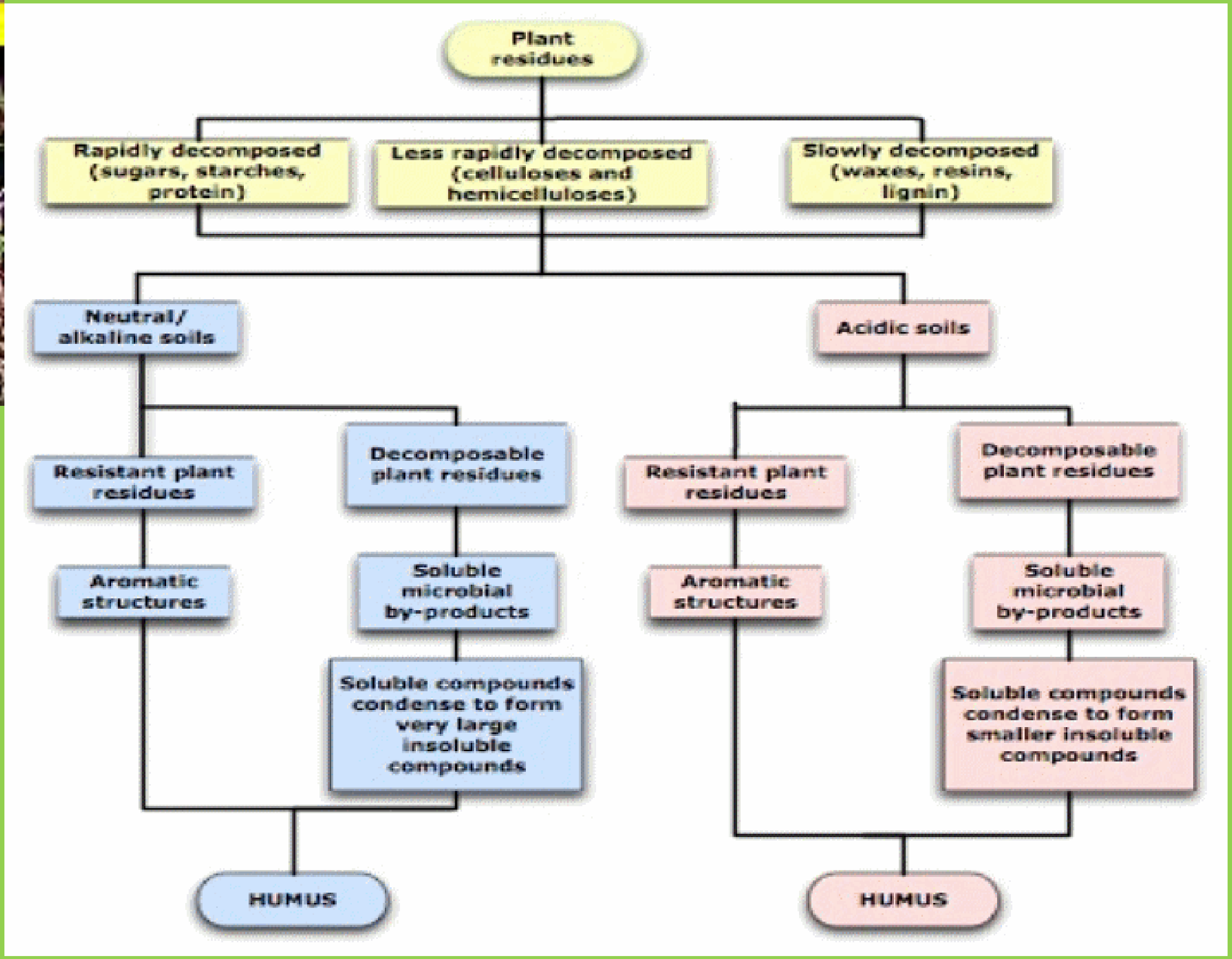
Soil Organic Matter

The key to managing a healthy soil community is to build organic matter. A soil test will let you know what percent of your soil is organic matter. This diagram is an ideal situation.



Humus

[What is HUMUS?](https://www.youtube.com/watch?v=8Q1VnwcpW7E)
https://www.youtube.com/watch?v=8Q1VnwcpW7E



http://www.bioag.com/humicfaqresources/faqforhumicacids.html

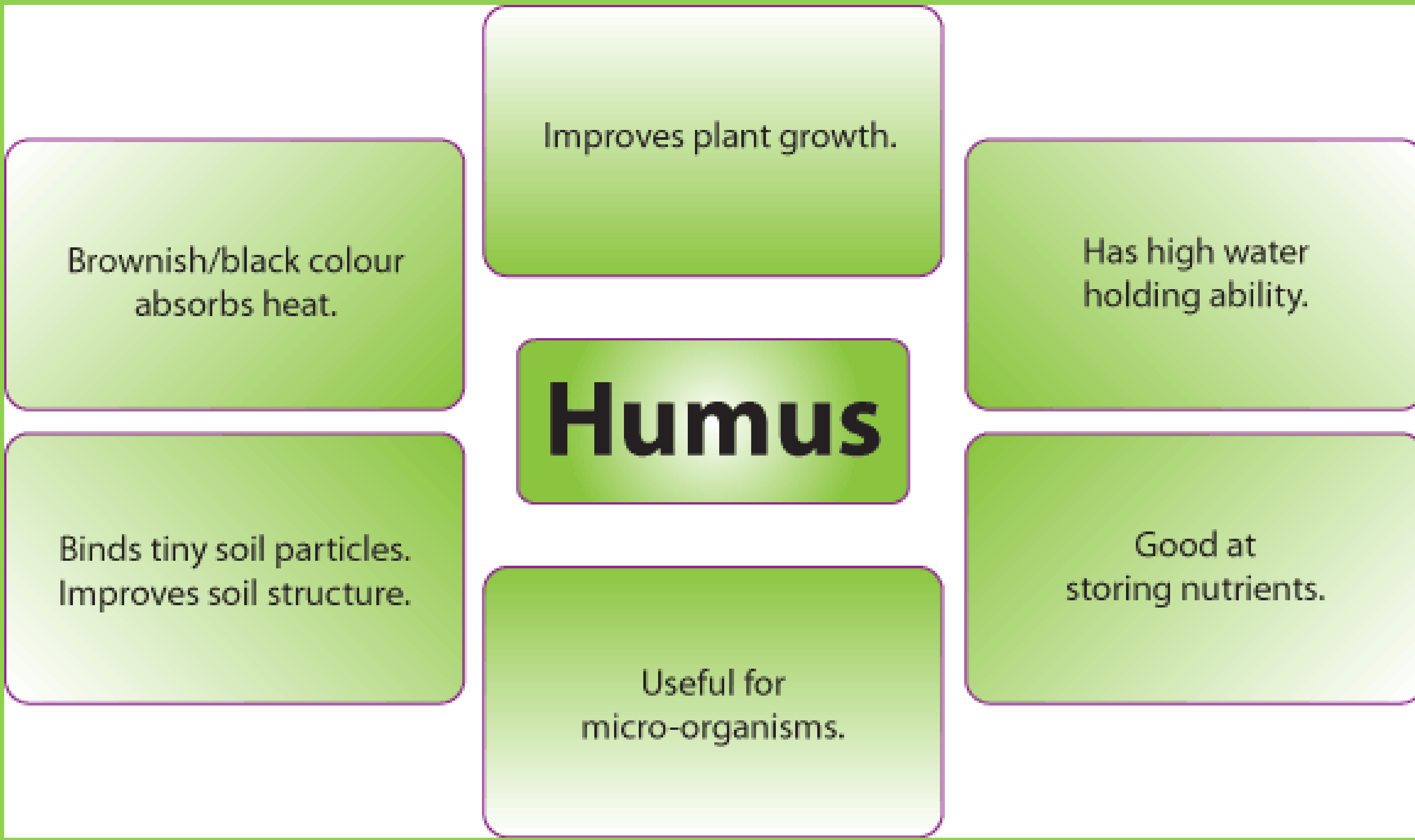
Humic Acid (organic compounds containing displaceable hydrogen), A natural Chelator.

http://www.teravita.com/Humates/Chapter2.htm

Humate (the salt of a humic acid, where hydrogen has been displaced by cations such as potassium, calcium, and magnesium)

Soil Organic Matter(SOM) , Matters!

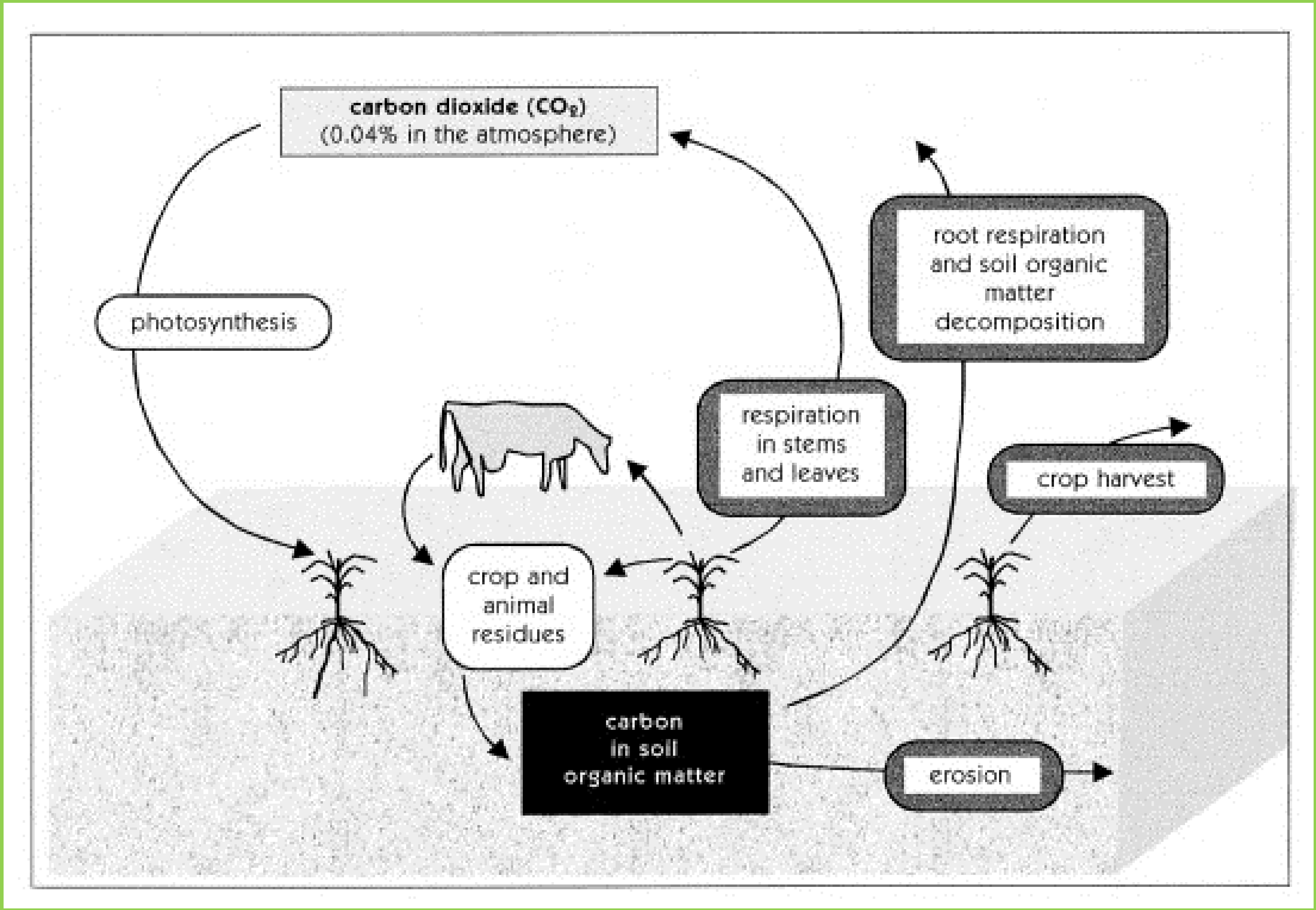
- Building Humus-Creating an environment for the biotic community
- Carbon Cycle – sinking Co2
- SOM and Managing the Nitrogen Cycle
- The key to Air and Water quality



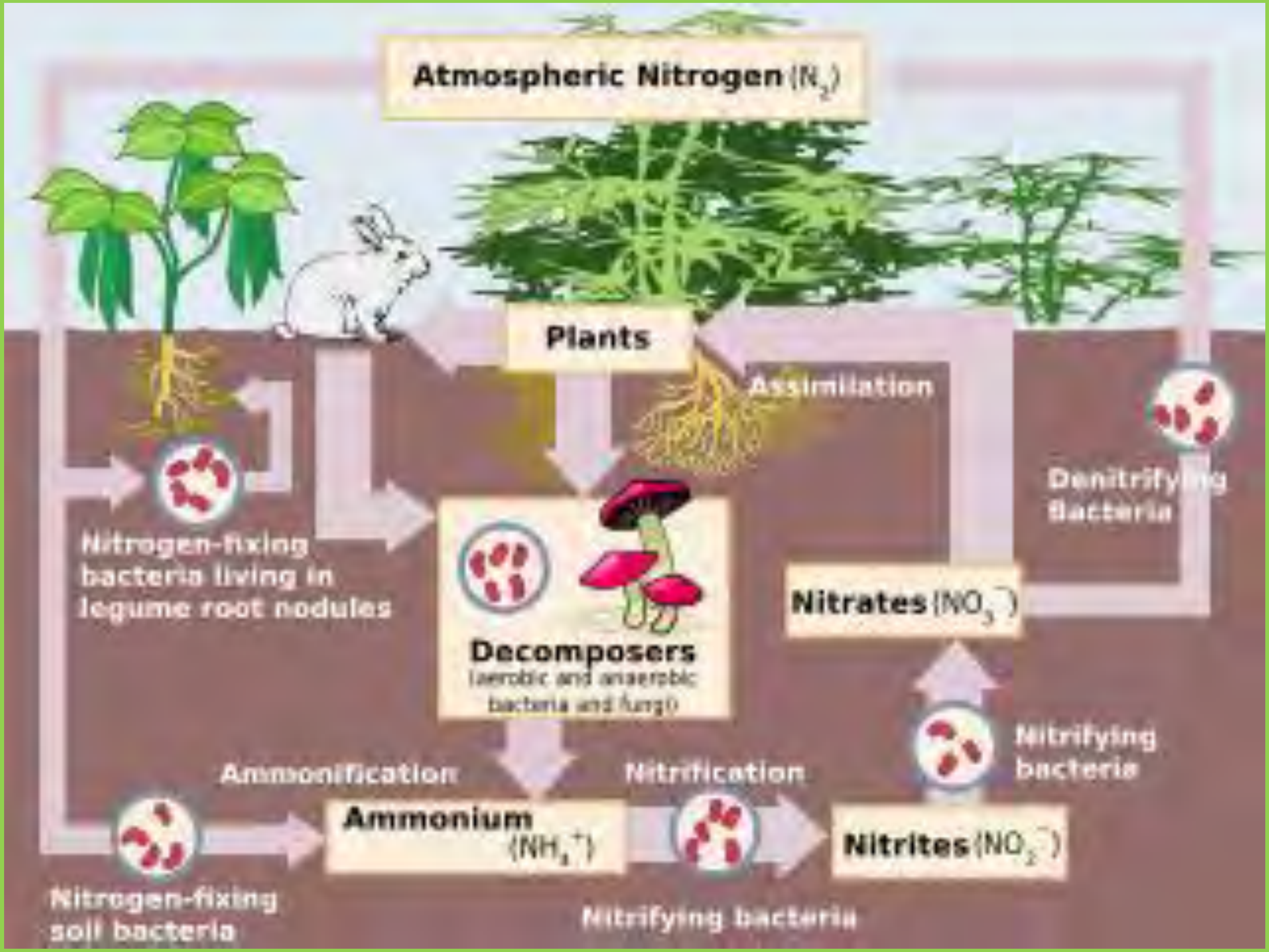
Humus is also a major contributor in sinking carbon emissions.

Soil Organic Matter and Sinking CO2

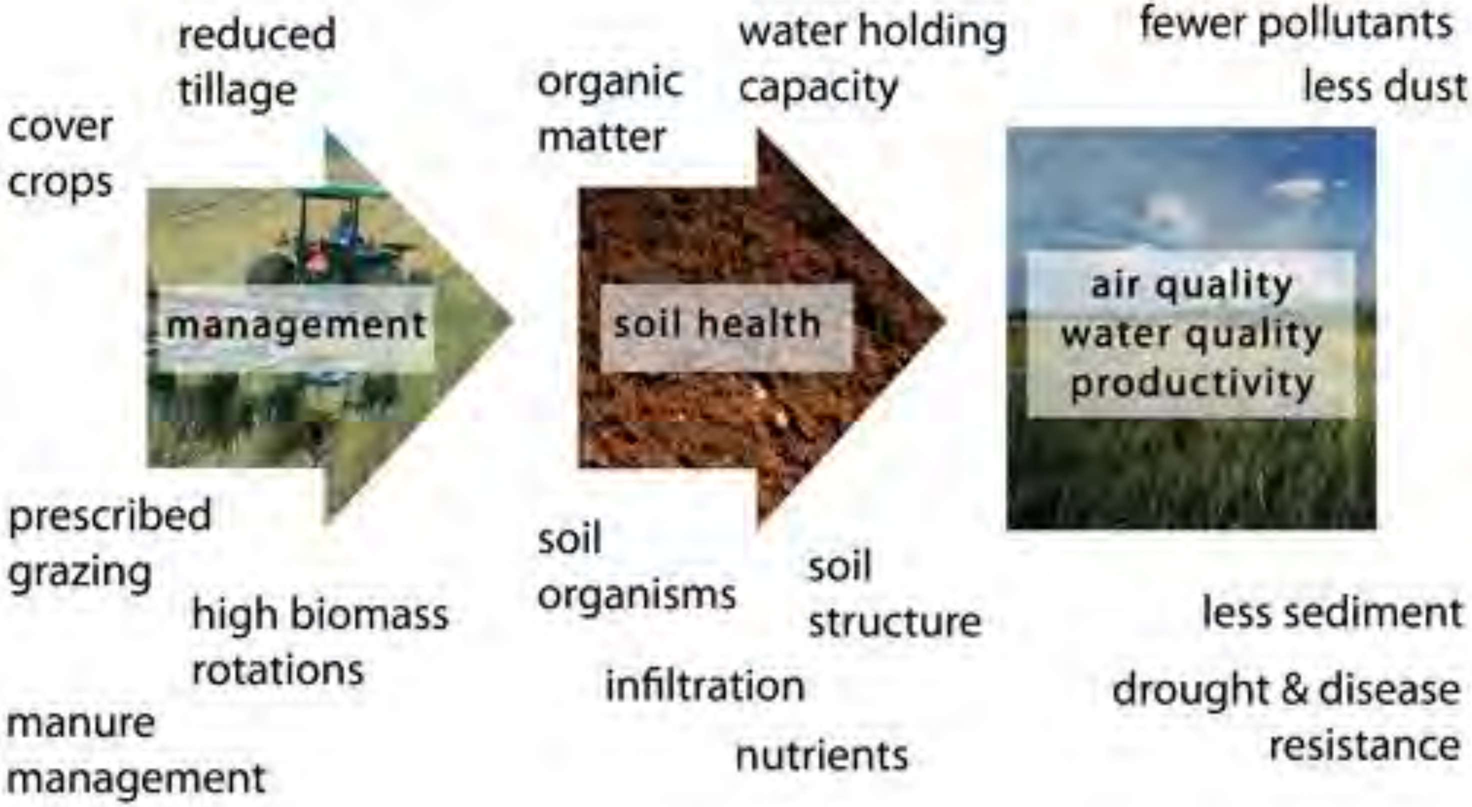
Carbon Cycle: role of C (CO2) and how to manage it.



SOM and Managing the Nitrogen Cycle



Managing soil organic matter is the key to air and water quality.



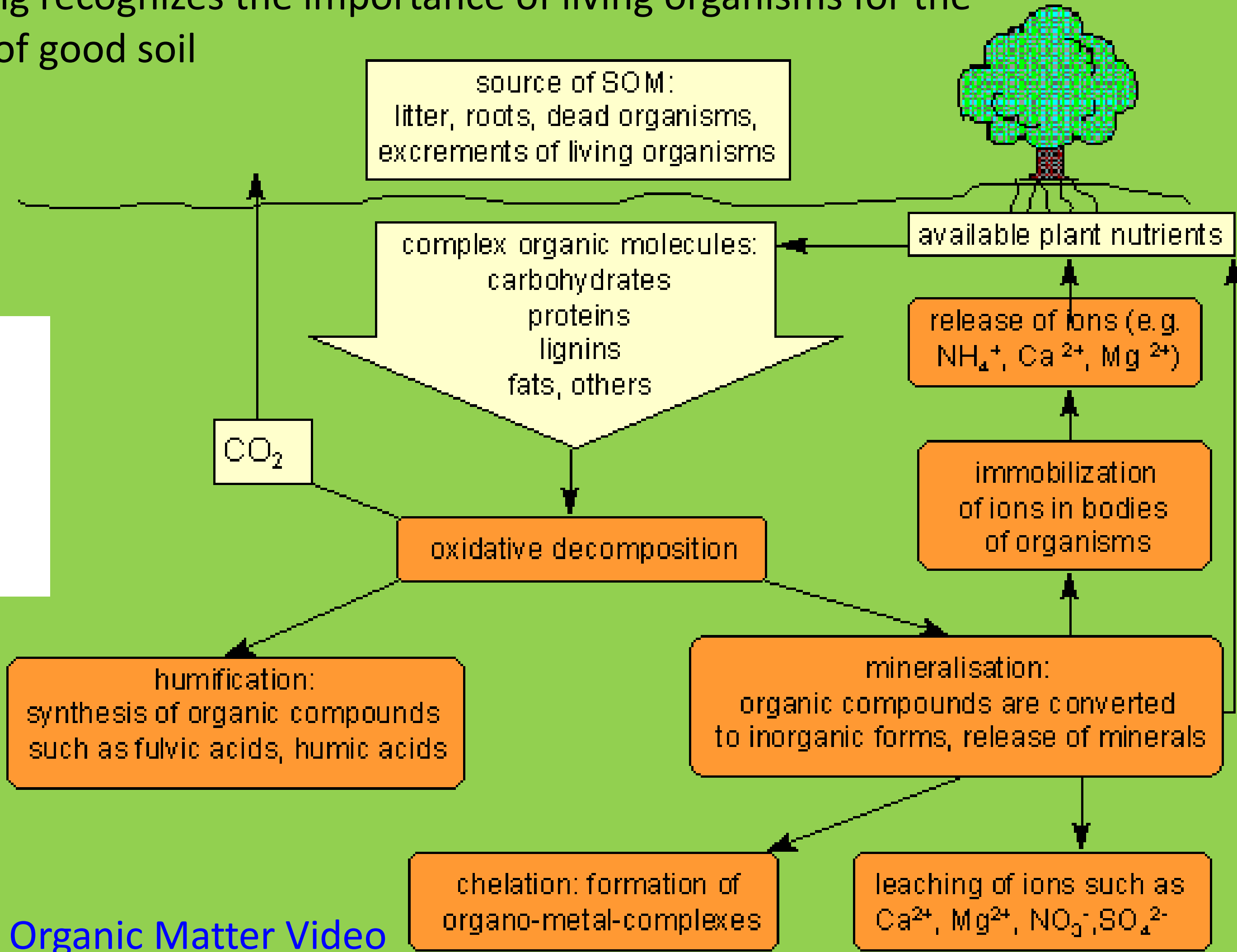
Building Organic Matter

- Compost*/Compost Teas*
- Cover cropping/Green Manures*
- Crop Rotation*
- Minimum Tillage*

* See SARE power point module on this topic for a complete lesson.

Comparing Organic and Commercial Farming

Organic farming recognizes the importance of living organisms for the development of good soil



Organic Farming depends on organic matter in the soil for soil health and nutrition.

[Importance of Soil Organic Matter Video](https://www.youtube.com/watch?v=z5zDD2q7PE8)

https://www.youtube.com/watch?v=z5zDD2q7PE8

Commercial farming uses harsh pesticides and fertilizers to create synthetically "good" soil. However, it is unnatural , harmful to the environment and unsustainable.

Assessment/Review

- How is soil formed?
- What are some important soil characteristics?
- Explain cation exchange capacity and how to improve it.
- Describe a cropping system that improves soil organic matter and enhances the soil biotic community.

Resources

- USDA.gov
  - http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/edu/
- Encyclopedia of the Earth
  - http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/edu/
- Beginning Farmers.org
  - http://www.beginningfarmers.org/the-nitrogen-cycle-agricultural-science-basics/
- Mosesorganic.org
- S.A.R.E.- previous grant projects

Farm Tools


PINCERS PUL
AND
TURNERS
BANGERS HANGERS
AND
STRAIGHTENERS

Learning Objectives

- Identify various tools by name
- Become familiar with safety measures required for each tool
- Learn about the proper technique for using each tool as well as their various uses
- Understand maintenance of each of these tools

Hand Tools in the Garden

- Shovel vs. Spade
  - A shovel is a basic digging tool with various head shapes depending on its use. The shovel head always comes to a point.
  - A spade is similar to a shovel but has a square head. They are often favored for digging shallow holes as well as moving around loose material.

  [more on shovels, spades, & shoveling]

- Trowel
  - a one-handed tool that resembles the shovel and spade. Due to its size, the trowel is favored when making more detailed/precise holes in the soil. Trowels are most used for transplanting or planting seeds in a garden.

- Hoe
  - This tool has a longer neck but a small head with various shapes depending on its use. The hoe is a common tool in gardening for making very shallow holes or even lanes in the soil as well as leveling out the ground and uprooting weeds.

Collinear Hoe: narrow blade used for slicing weeds

Scuffle/Stirrup Hoe: Blade cuts through tough weeds fast and in both directions

Standard Garden Hoe: average hoe used for various tasks

Dutch Hoe : blade designed to push/pull weeds just below the surface

Loop Hoe

- Rake

Rakes are used to comb the top of your garden and pick up loose material. The garden rake's "teeth" can dig into the ground to pull up loose material, moving around mulch and removing weeds. The leaf rake gently moves lighter materials to the desired locations.

[Garden/Gravel Rake]

[Lawn or Leaf Rake]

- Cultivator
  - similar to the rake, a cultivator has thick metal “teeth” that can pull up loose top soil and other material. Digs deeper into the ground than rake so does not drag leaves/mulch/weeds as well.


Hand Cultivator


Mobile Cultivator


Hand Mattock

Pruning Tools

Used to cut or prune plants and trees

Pruner

Folding hand saw

Shears or loppers

[Tree Pruning Tools]

Wheelbarrow

- Used to move material from one place to another

Garden Hand Tool Safety

- Using many of these tools can be strenuous work and can cause back pain, make sure to take breaks and stretch periodically.
- Check the terrain you are working with is clear of wires and underground cables/pipes.
- Wear sturdy close-toed shoes as well as gloves to prevent hot spots and blisters from forming.
- Consider wearing long pants to cover the skin completely.

Garden Tool Maintenance

There are many tasks that require your attention in a garden, so there will be times when you need to put down your tools. When doing so:

- Place the tool in plain sight and tell those around you where you left it.
- If you have something to lean it up against, do so with the metal edge facing away. This prevents someone stepping on the tool and getting hurt.
- Although most of the above tools can handle rain or a single storm, long term exposure will damage your tools. So it is better to properly store them in the first place rather than leave them out overnight.

Garden Maintenance

- Long-term storage
  - Have your garden tools organized (by type or use) and stored in a place that protects from the weather.
  - Tool racks in sheds or garages are often used. Here's another idea!

Cleaning & Sharpening

- Removal of debris
  - It is important to remove any dirt or debris that you may have collected while working with the tools. This prevents wear and other damage to the tool.
- Examining the tool
  - Look over your tool and pay attention when using it to evaluate its quality. You can often feel when a tool is not performing as well as it should, this is a sign that either maintenance needs to be done or you may need a new tool.
- Sharpening edges
  - Whetstones: small rectangular stone used for small blades and edges
  - Dremel: an electric handheld device with a variety of head attachments that are useful for sharpening complicated edges and groves (i.e. saws, mower blades)
  - Bench sharpening: a composite wheel that rotates at high speeds (adjustable) and has a number of coarseness levels and wheel types.

Field-Scale Implements

- Used on larger plots of crops.
- Replaces the work done by horses, humans, or other animals.
- These machines can till soil, plant seed, harvest, thresh grain, bale hay, move and remove items—eliminating some back-breaking work for farmers.
- The key is to know when to use them, how to use them, and how to fix them when they break down.

Field-Scale Implements

- Tractors
- Manure spreaders
- Cultivators
- Tillers
- No-till seeders

Tractors

- Serves multiple purposes which include plowing, tilling, discing, harrowing, and planting. Maximizes output, minimizes labor- can play an important role on a small farm if the operation is large enough to justify its use

Walk Behind Tractor

- This tool can be utilized in a variety of different ways including tilling, mowing, and cultivating , with lower fuel use than a full size tractor   walk behind tractor in action

Manure spreader

Evenly distributes manure for proper fertilization of crops.

[restoring an old horse drawn manure spreader]

[new small manure spreader]

Tiller (rotary hoe)

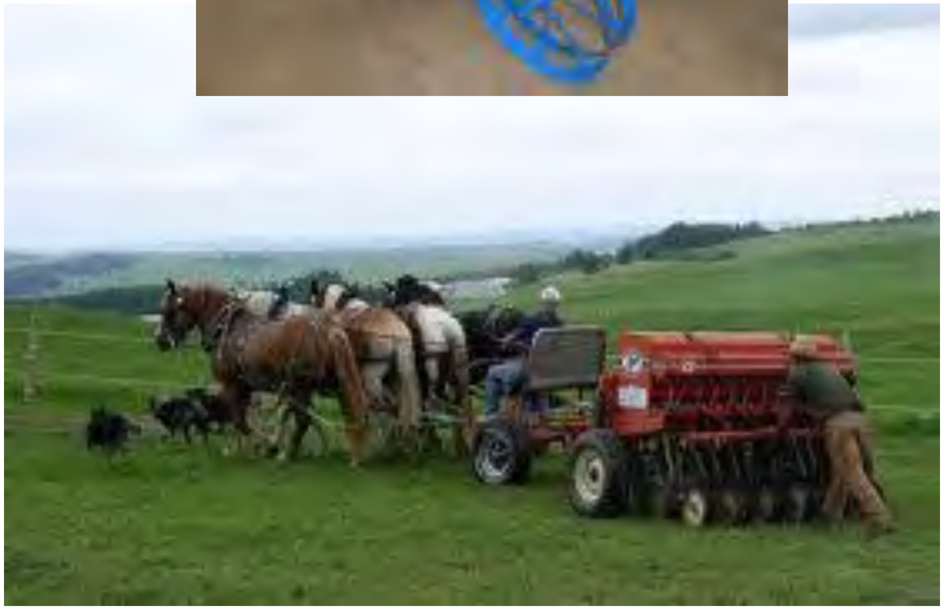
- Tilling is the process of preparing the soil for planting by agitating it and opening it up.
- Machines like the ones shown here move the soil, level it, and remove old plants.
- Power take-off (PTO) required to operate tractor drawn models

Walk behind

Tractor drawn

No-till seeder

- Tilling can often disturb the soil too much, which decreases moisture, nutrients and causes erosion.
- No till planting uses seeders like these to place the seed in the soil without opening it up too much.



Cultivator

- Stirs up and moves the soil around.
- It is used before planting to aerate the soil or carefully, once the plants are in place, to take out weeds.

Wheel Disc Cultivator

- After soil has been initially worked up, wheel shaped discs are used to further break up and aerate the soil
- Like most other field-scale machines it can be either horse-drawn or tractor pulled

[Discing a Garden]

Livestock Tools & Equipment

- Halters
- Stanchions
- Chicken Coops
- Animal Care Tools
- Hay Handling
- Fencing Tools

Halters

- Used to lead or tie up an animal.
- Halters circle around

  the nose→under the chin

  →behind the ears, then

  fastened to a rope or

  chain to lead.

Stanchions

- Vertical structures built to hold animals in place during milking or veterinary care
- A feeding trough is placed in front of them so they can eat while being milked.

Movable chicken coop (chicken tractor)

- A house for female chickens to protect them from bad weather and predators.
- This coop has an open-air patio so the hens can get some fresh air to stay healthy when weather permits.
- Wheels make it a mobile home.

Animal Care Tools

- Hoof trimmers & hoof pick
  - Hoof care important to hoof health

Goat or sheep hoof trimmer

Picking out a horse's feet

- Castration & tail docking
  - Bloodless elastrator can Be used when animal is young

Hay handling

Large round bale stacker

Large bale spear

Hay elevator makes loading small square bales of hay in the loft easy!

[Making Small Square Bales]

Fencing Tools

Post hole digger

Comealong

Crimp tool

Homemade fence stretcher

Fencing tool

[Field Fence Installation Part 1]

[Field Fence Installation Part 2]

Self-Review Questions

- Why is it important to properly store tools when they are not being used?
- Why is a well-maintained tool safer than a rusty, dirty, or dull edged tool?
- Which tools are best for weeding?

how to design and use a

Working Calendar

- Identify the benefits of using a detailed working calendar to manage farm work.
- Understand the components of a successful working calendar.
- Understand how to create a valuable working calendar.
- Learn how to use the calendar after it is created.

Learning objectives

Easy online tools for creating and sharing calendars:

http://www.growingproduce.com/video/pest-control/v-nine-steps-to-creating-a-pest-management-calendar-for-your-farm/

Starting out: See an example.

- The products of farming take time to grow and are often affected by seasonal conditions.
- The prudent farmer acts like the conductor of a symphony, setting the stage and encouraging the different players *at the right time* in order to convey a cohesive flow of produce.
- Just as the conductor consults a score, the farmer may consult a calendar in order to coordinate work.

Production takes time.

- A working calendar is a multi-functional tool. A calendar may prove useful in organization, record-keeping, and communication. Its benefit may be as tangible as a wheelbarrow’s mechanical advantage.
- Production goals give our calendar purpose. Considering these along with a working knowledge of natural processes, we lay out tasks over time.

				calendar				record-keeping
production goals	>	relevant information	>	planned work	| > |	actual work	>	results

example:

harvest 10 lbs. of arugula in May	>	arugula* typically matures in five weeks given spring weather	>	prepare bed and seed arugula April 1, pull weeds mid-April, harvest early May.	| > |	prepare bed and seed arugula on April 1, weed on April 9 and 22, harvest May 3.	>	11 lbs. of arugula harvested on May 3

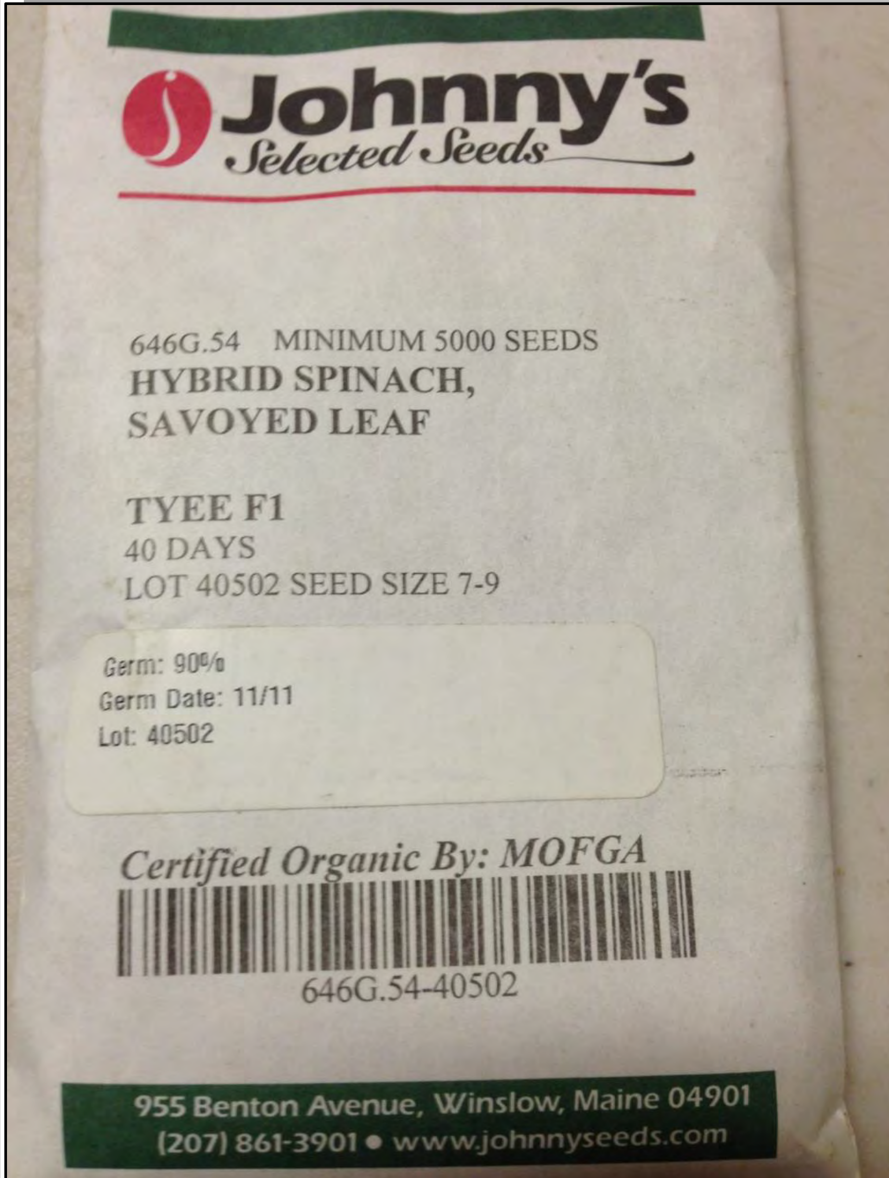
*link is to Johnny’s Selected Seeds’ arugula seed, see “Growing Info” under purchase area.

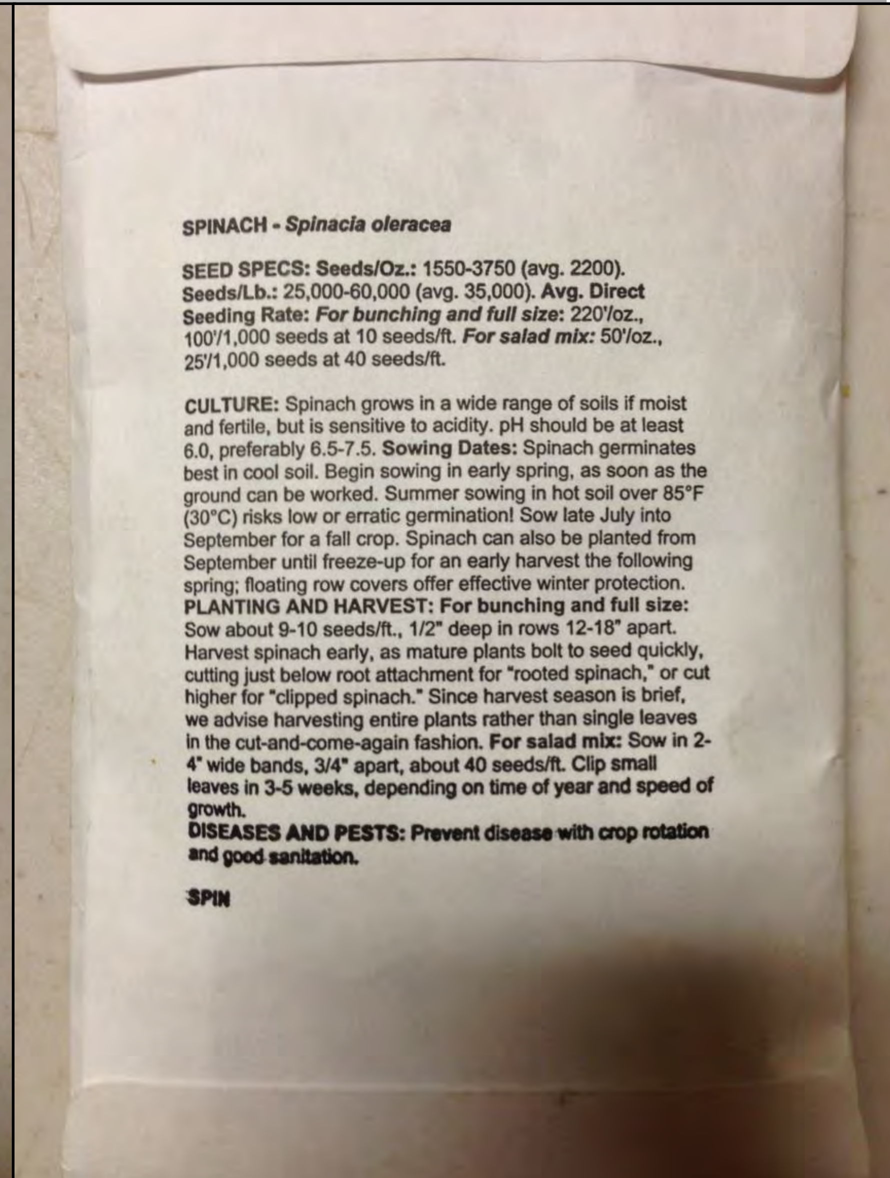
- We would like to harvest spinach for as much of the year as possible. On what does this depend?

For starters, let's consider weather conditions, soil properties, the variety of spinach we're dealing with, and our labor. Pretend we have a plot of ideal soil near Niles, Michigan. We know the local climate and have a packet of spinach seeds with included variety detail (shown on following slide, and identically under "Growing Info" tab http://www.johnnyseeds.com/p-7449-tyee-f1.aspx) informing our planting.

Read the following slide and decide: what should be done.

Imagine we are growing spinach.


Johnny's
Selected Seeds
646G.54 MINIMUM 5000 SEEDS
HYBRID SPINACH,
SAVOYED LEAF
TYEE F1
40 DAYS
LOT 40502 SEED SIZE 7-9
Germ: 90%
Germ Date: 11/11
Lot: 40502
Certified Organic By: MOFGA
646G.54-40502
955 Benton Avenue, Winslow, Maine 04901
(207) 861-3901 • www.johnnyseeds.com


SPINACH - Spinacia oleracea
SEED SPECS: Seeds/Oz.: 1550-3750 (avg. 2200). Seeds/Lb.: 25,000-60,000 (avg. 35,000). Avg. Direct Seeding Rate: For bunching and full size: 220'/oz., 100'/1,000 seeds at 10 seeds/ft. For salad mix: 50'/oz., 25'/1,000 seeds at 40 seeds/ft.
CULTURE: Spinach grows in a wide range of soils if moist and fertile, but is sensitive to acidity. pH should be at least 6.0, preferably 6.5-7.5. Sowing Dates: Spinach germinates best in cool soil. Begin sowing in early spring, as soon as the ground can be worked. Summer sowing in hot soil over 85°F (30°C) risks low or erratic germination! Sow late July into September for a fall crop. Spinach can also be planted from September until freeze-up for an early harvest the following spring; floating row covers offer effective winter protection.
PLANTING AND HARVEST: For bunching and full size: Sow about 9-10 seeds/ft., 1/2" deep in rows 12-18" apart. Harvest spinach early, as mature plants bolt to seed quickly, cutting just below root attachment for "rooted spinach," or cut higher for "clipped spinach." Since harvest season is brief, we advise harvesting entire plants rather than single leaves in the cut-and-come-again fashion. For salad mix: Sow in 2-4" wide bands, 3/4" apart, about 40 seeds/ft. Clip small leaves in 3-5 weeks, depending on time of year and speed of growth.
DISEASES AND PESTS: Prevent disease with crop rotation and good sanitation.
SPIN

- Using the information we can harvest spinach for most of the spring, summer and fall if we plant beds in two-week intervals from late April through early October with a break during the hottest part of summer. We will water, spray compost tea, and weed the beds occasionally during growth. We build the following calendar for **April Spinach Planting**:

	M	Tu	W	Th	F	Sa	Su
April		1 Planting #1	2	3	4	5	6
	7	8	9 Compost Tea and Weed All Spinach	10	11	12	13
	14	15 Planting #2	16 Compost Tea and Weed All Spinach	17	18	19	20
	21	22	23 Compost Tea and Weed All Spinach	24	25	26	27
	28	29 Planting #3 Check P#1 for insect pressure	30 Compost Tea and Weed All Spinach				

So our **May Spinach Calendar** would look like this:

	M	Tu	W	Th	F	Sa	Su
May				1	2	3	4
	5	6	7 Compost Tea and Weed All Spinach except the planting to be harvested this week	8	9	10 Begin Harvest Planting #1	11
	12	13	14 Compost Tea and Weed All Spinach except the planting to be harvested this week	15	16	17	18
	19	20	21 Compost Tea and Weed All Spinach except the planting to be harvested this week	22	23	24 Begin Harvest Planting #2	25
	26	27	28 Compost Tea and Weed All Spinach except the planting to be harvested this week	29	30		

Making a like calendar for each crop family makes it easy to collate monthly work calendars giving farmer and employees an overview of all work, monthly, weekly and daily(slide 16).

- What are your production goals? What factors affect their fulfillment? What labor will be required of you, and when should each task be performed? This is the first step to building a calendar, and might involve quite a bit of thought and research.

Now, imagine your own farm.

Do your research.

Common factors relevant to growing food, with related research sources, include:

- crop and breed characteristics
  - Rodale Institute's organic transition module (click "Crops" on left navigation bar)
  - USDA plants database (hint: to view only edible plants, use the advanced search's "human palatable" filter at bottom of criteria list)
  - Purdue's breakout map of U.S. Agriculture Census crops
  - Johnny's Selected Seeds' planting calculators
  - Heritage breed animal information
- soil quality
  - Johnny's Selected Seeds' soil primer (article includes further links)
  - Rodale Institute's organic transition module (click "Soils" on left navigation bar)
  - USDA/NRCS soil education hub
  - *Building Soils for Better Crops* (free download)
- local climate
  - interactive map of major U.S. climate organizations
  - Midwestern Regional Climate Center
  - Indiana State Climate Office's hub for normal climate data by region

Common farming work involves:

- **soil** testing, amendment, and cultivation
- **compost** development and application
- **plant** seeding, transplanting, pruning, and spraying
- **plant bed** irrigation, weeding, and mulching
- **season extension** as through greenhouse use
- **produce** harvest, washing, storage, and transportation
- **regulation** of production as through staggered plantings
- **animal** housing, watering, feeding, herding, and treatment
- **tool and workspace** construction, cleaning, and organization
- **workforce** cycling and growth
- **sourcing** supplies

Consider your work.

- With an idea of the conditions and work it will take to yield your food, you may consider your calendar's specifications.
- What is a useful timeframe for your calendar? Animals are often fed twice daily, plants take weeks or months to grow, crop rotation occurs over the course of a year or years, and soil-building may take decades. What are you trying to accomplish and how might one or more calendars be scaled to help?
- What form will your calendar take? Shared online documents, month-by-day whiteboards, and penciled list arrangements are some of the possibilities. Tasks may be assigned to workers within the calendar. What is most useful to you and your workforce?
- See http://youtu.be/lik8MRqr7Kk for information on online calendars.

Design your calendar.

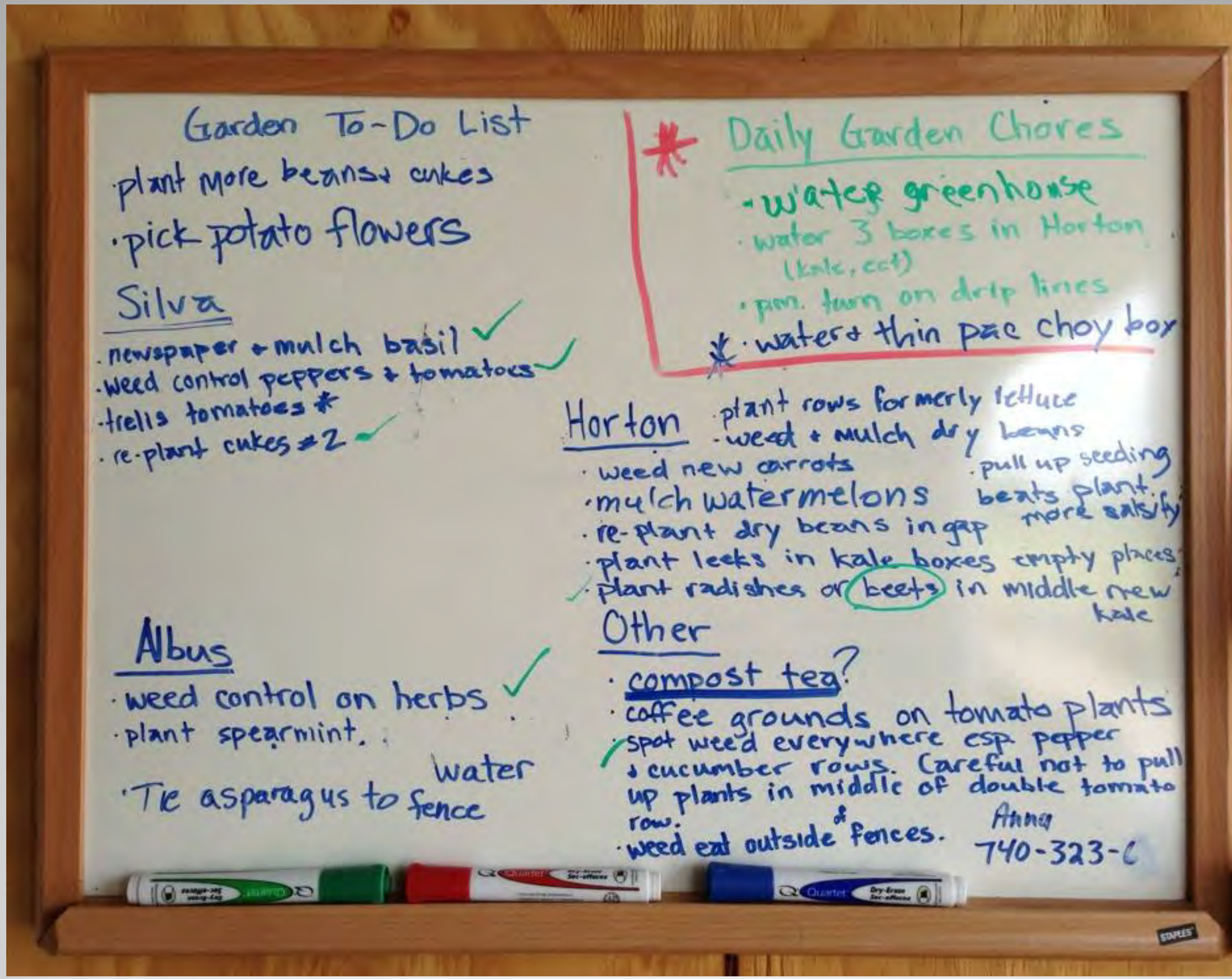
- What items will your calendar include? How will these items be categorized and organized?
- In placing tasks, you might work back in time from desired outcomes or forward from landmarks such as the year’s expected final day of freezing weather.
- How far in advance will you fill your calendar? How will you update your calendar? Commonly, farmers do more planning in winter and reacting in summer.

Design your calendar.

- Once you have built a calendar, consult it as often as is necessary to direct your labors. Like any tool, it might need maintenance to remain useful.
- When you feel like change is in store, evaluate your calendar’s performance and change it accordingly.
- After years your calendar will be a finely tuned tool.

Work with your calendar.

Check out some calendars.


Garden To-Do List
plant more beans & cukes
·pick potato flowers
Silva
·newspaper & mulch basil
·weed control peppers & tomatoes
·trellis tomatoes *
·re-plant cukes #2
Albus
·weed control on herbs
·plant spearmint.
water
·Tie asparagus to fence
Daily Garden Chores
·water greenhouse
·water 3 boxes in Horton (kale, ect)
·p.m. turn on drip lines
·water & thin pac choy box
Horton
·plant rows formerly lettuce
·weed & mulch dry beans
·weed new carrots
·mulch watermelons
·re-plant dry beans in gap
·plant leeks in kale boxes empty places
·plant radishes or beets in middle new kale
·pull up seeding beats plant more salsify
Other
·compost tea?
·coffee grounds on tomato plants
·spot weed everywhere esp. pepper & cucumber rows. Careful not to pull up plants in middle of double tomato row.
·weed eat outside & fences.
Anna
740-323-

Nofarm Farm 2013	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Greenhouse			start brassicas and tomatoes	shoots	shoots	shoots	shoots	shoots	clean and repair			
East Field			mow and till	transplant brassicas	cultivate	harvest	harvest	clear to carrots	cultivate	cultivate		
North Field				mow and till	transplant tomatoes	cultivate	harvest	harvest	clear to buckwheat			
West Field				mow and till	start corn	cultivate	cultivate	harvest	clear to buckwheat			
Boxes				clean and compost	plant greens	plant greens	plant and harvest	harvest	harvest	clean and repair		
Pasture				graze birds	cut	graze birds	cut	graze birds	cut			
Compost	fill and turn	fill and turn	fill and turn	fill and turn, apply	fill and turn, apply	fill and turn, apply	fill and turn	fill and turn	fill and turn	fill and turn	fill and turn	fill and turn
Tools		clean and sharpen		clean and sharpen		clean and sharpen		clean and sharpen			repair	
House	misc. work	misc. work	clean and repair				ferment cabbage	dry corn and tomatoes		knit	clean and repair	misc. work

Check out some calendars.

- Calendars have myriad forms and uses. Consider the spectrum.
- A task-list is a calendar aggregating work items for a given timeframe.
  - Consider a temporary checklist of the day’s goals.
  - Consider a relatively permanent display of work that can always be done. This could prove useful when volunteer labor shows up or as a reminder and inspiration.
- A calendar can serve as a data collection tool. Interesting data (perhaps on temperature, rainfall, germination, harvesting, pests) recorded by date may inform future farming endeavors.
- On a related note, a working calendar that is complete and adhered to is a reliable account of farm activity. This may be useful in all sorts of analysis.

Consider the possibilities.

1. How are seed packets and crop information critical to developing a working calendar?
2. In what ways can calendars be a useful communication tool among farm workers?
3. How can a working calendar help farmers meet their production goals?

Self-Review Questions

Resources

- Greenhorns' free publications library
- National Sustainable Agriculture Information Service (ATTRA)
- USDA / AFSIC on organic production
- Johnny's Seeds

Sustainable Business Planning

An Organic and Permaculture Approach

6-10-13

Objectives

- Student will gain understanding of basic principles of a “sustainable” business
- Student will learn how to measure farm work productivity and measure profitability

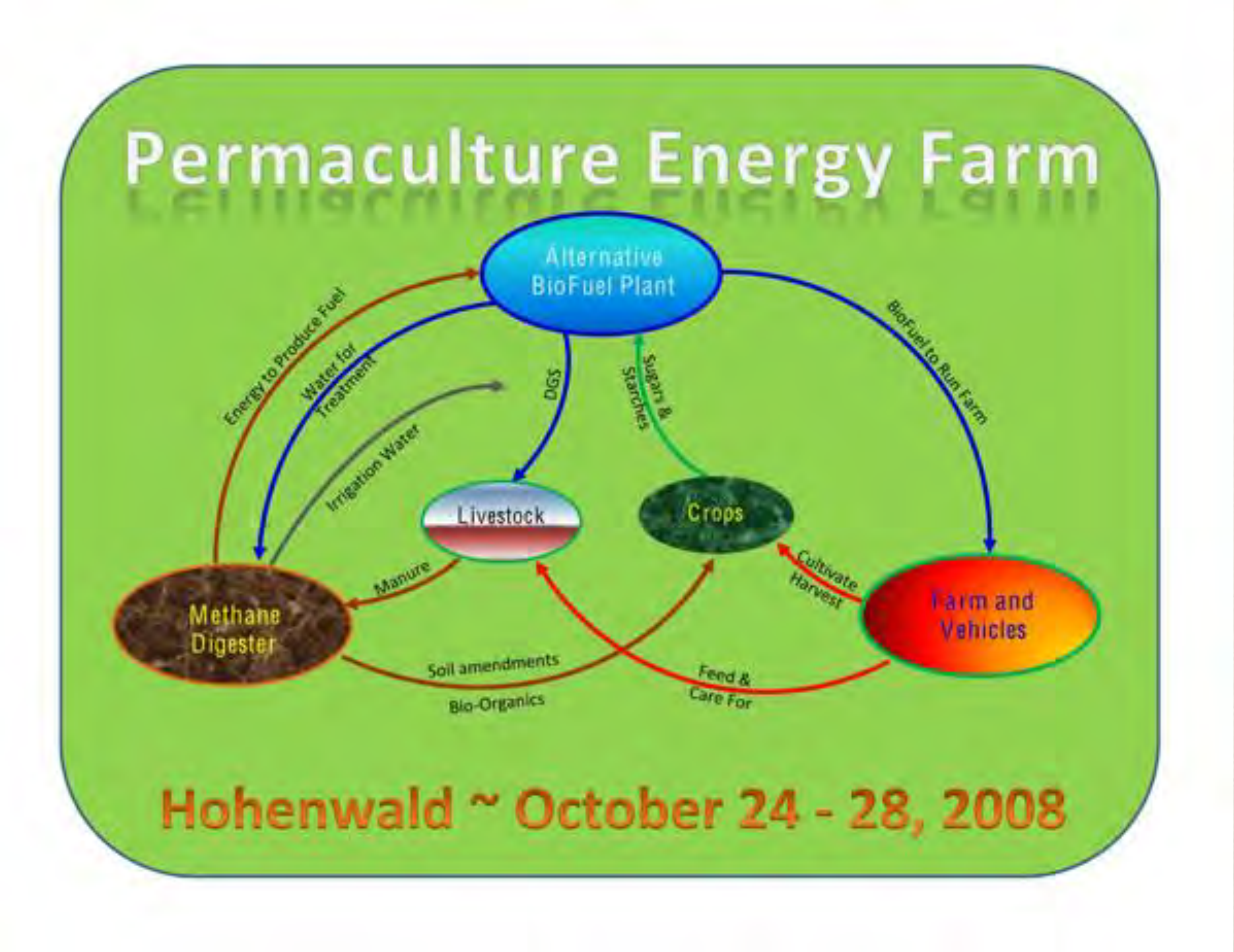
Definitions

- sustainable: a practice that does not deplete natural resources
- gross sales: overall total income before expenses
- expense: cost or charge
- net profit: gross sales minus expenses

A sustainable farm...

- Provides a living for the farmers AND improves the quality of the land
- Wendell Berry: In addition to asking, “How can this land provide our living?” also asks, “What does the land need?”

Permaculture looks at the whole cycle of a farm when designing the farm system



A sustainable and permaculture business...

A sustainable organic and permaculture-based farm takes into account more than money.

There are 3 parts:

1. Social
2. Environmental
3. Economic

1. Social

- How are people impacted? What are the impacts of your farm methods on your local community? On your family? On you? On people thousands of miles away?

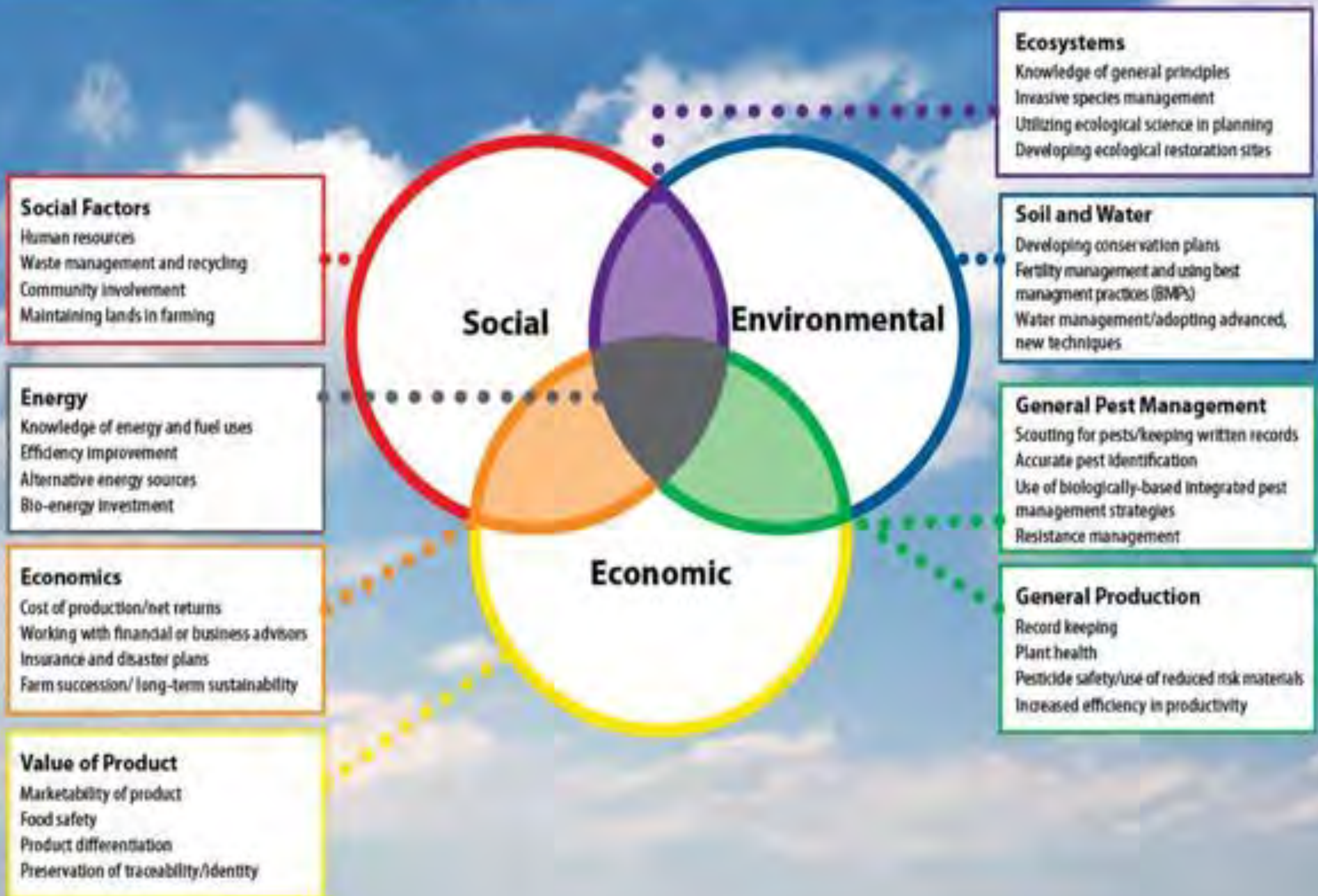
2. Environmental

- How is the air affected by your farm? The soil? The water?

3. Economic

- Does your farm produce enough to pay the bills?

Three Elements of Sustainability



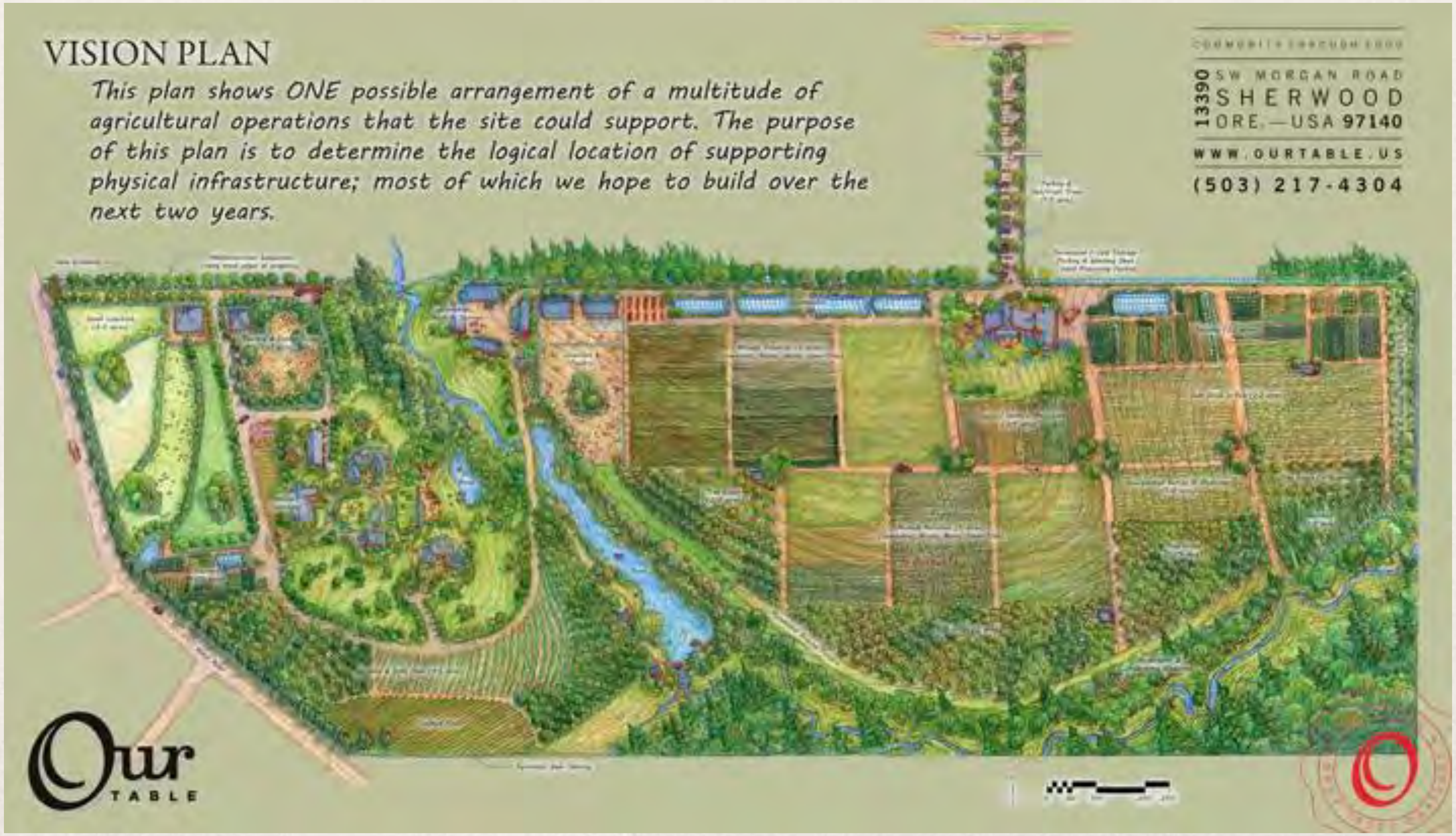
Consider these 10 successful practices in designing your sustainable farm business

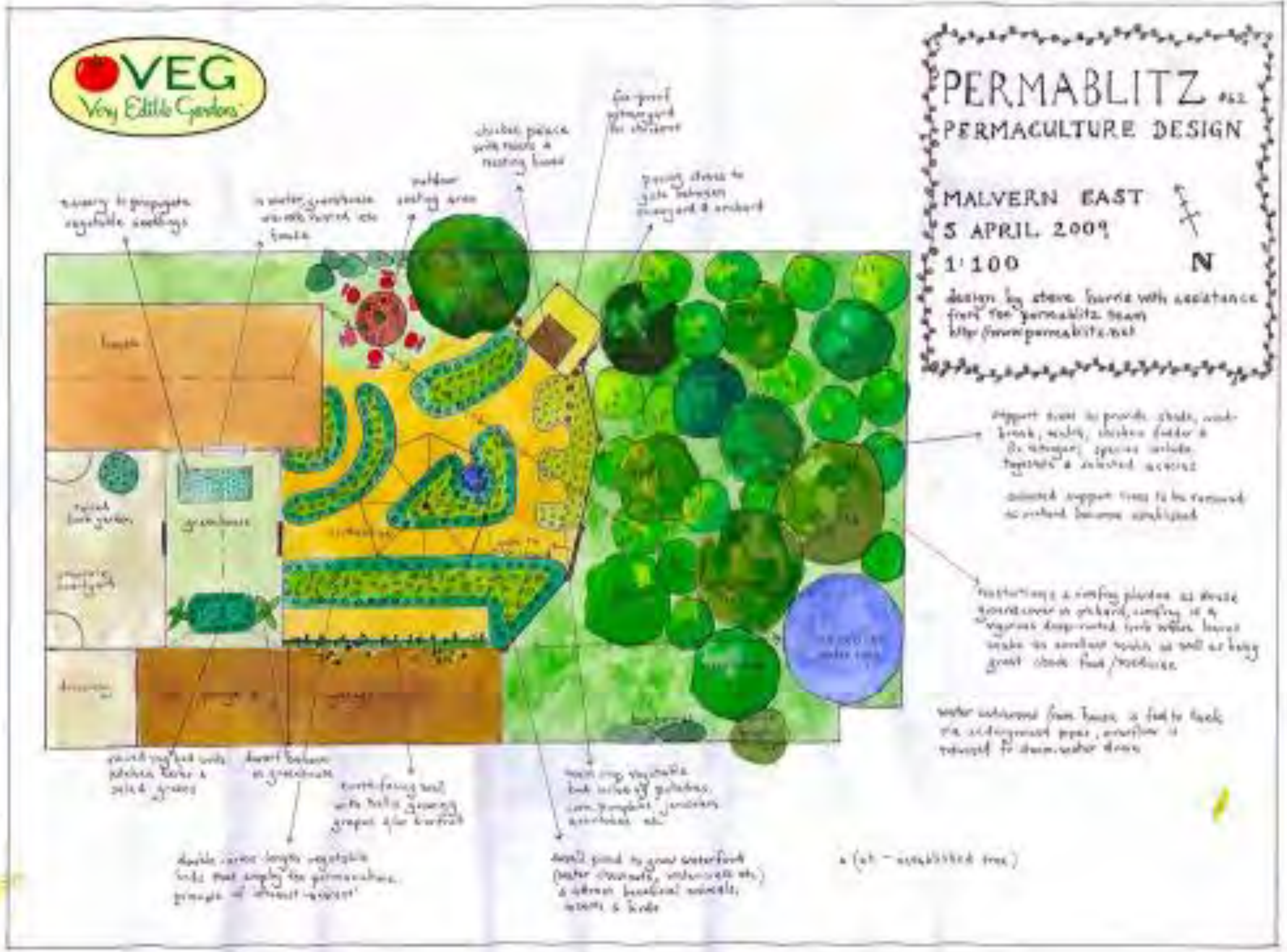
1. Make a plan
2. Develop a soil fertility plan
3. Plan a sustainable production system
4. Develop sustainable markets
5. Track your income
6. Track and trim your expenses
7. Plan your expenses
8. Create a smooth work flow
9. Level the load
10. Remember to give back

Let's look at each step…

1. Make a plan

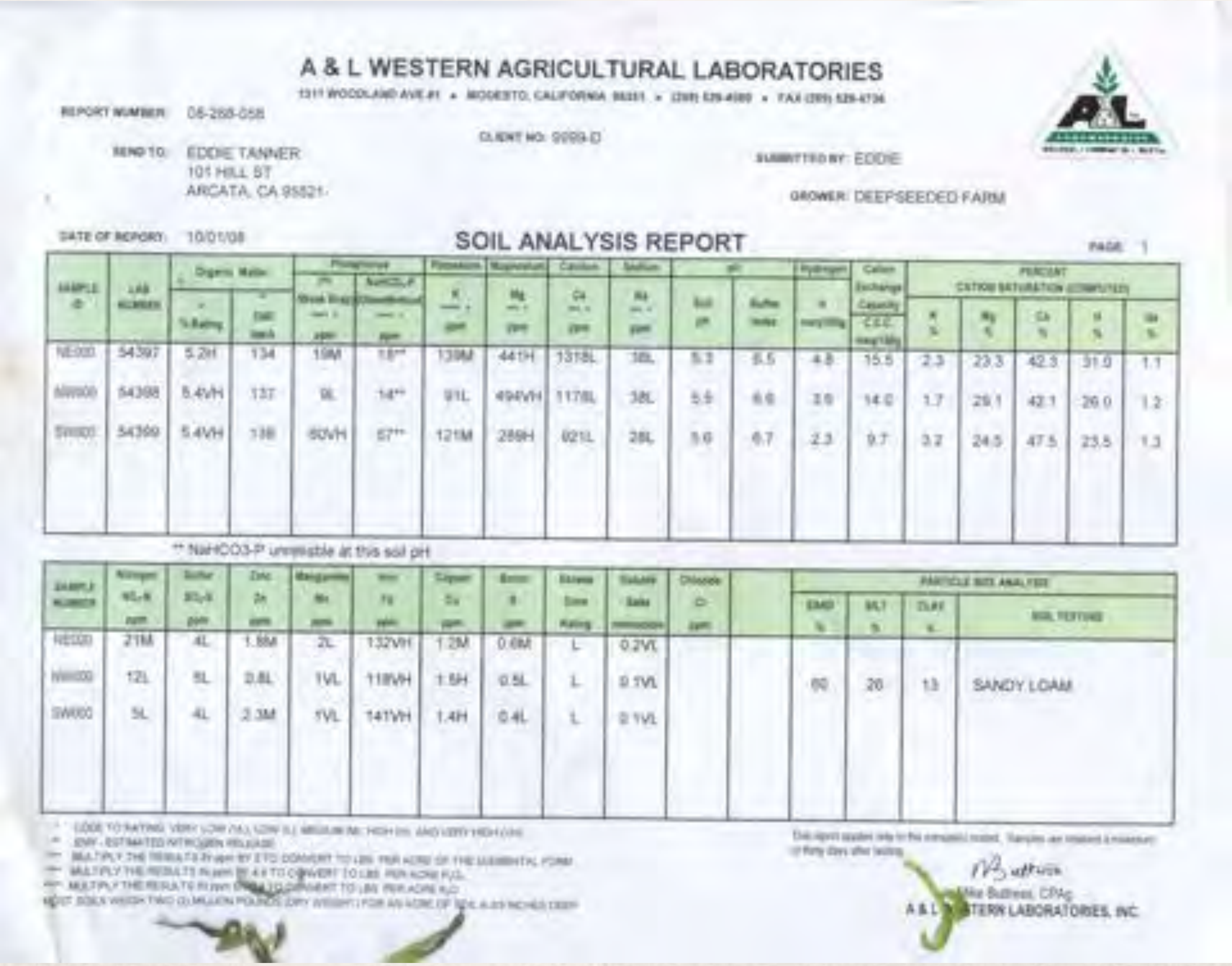
The first step is to make a plan-
--project your sales
--lay out your farm on paper




VEG
Very Edible Gardens
PERMABLITZ
PERMACULTURE DESIGN
MALVERN EAST
5 APRIL 2009
1:100
N

2. Develop a soil fertility plan

Get a soil test and make short and long-term plans to amend soil



A & L WESTERN AGRICULTURAL LABORATORIES

1311 WOODLAND AVE #1 • MODESTO, CALIFORNIA 95351 • (209) 529-4080 • FAX (209) 529-4736

REPORT NUMBER: 08-268-058

CLIENT NO: 9999-D

SEND TO: EDDIE TANNER
101 HILL ST
ARCATA, CA 95521-

SUBMITTED BY: EDDIE

GROWER: DEEPSEEDED FARM

DATE OF REPORT: 10/01/08

SOIL ANALYSIS REPORT

PAGE: 1

SAMPLE ID	LAB NUMBER	Organic Matter % Rating	Organic Matter ENR lbs/A	Phosphorus P1 (Weak Bray) ppm	Phosphorus NaHCO3-P (Olsen Method) ppm	Potassium K ppm	Magnesium Mg ppm	Calcium Ca ppm	Sodium Na ppm	pH Soil pH	pH Buffer Index	Hydrogen H meq/100g	Cation Exchange Capacity C.E.C. meq/100g	Percent Cation Saturation K %	Mg %	Ca %	H %	Na %
NE000	54397	5.2H	134	19M	18**	139M	441H	1318L	38L	5.3	6.5	4.8	15.5	2.3	23.3	42.3	31.0	1.1
NW000	54398	5.4VH	137	9L	14**	91L	494VH	1178L	38L	5.5	6.6	3.6	14.0	1.7	29.1	42.1	26.0	1.2
SW000	54399	5.4VH	138	60VH	57**	121M	289H	921L	28L	5.6	6.7	2.3	9.7	3.2	24.5	47.5	23.5	1.3

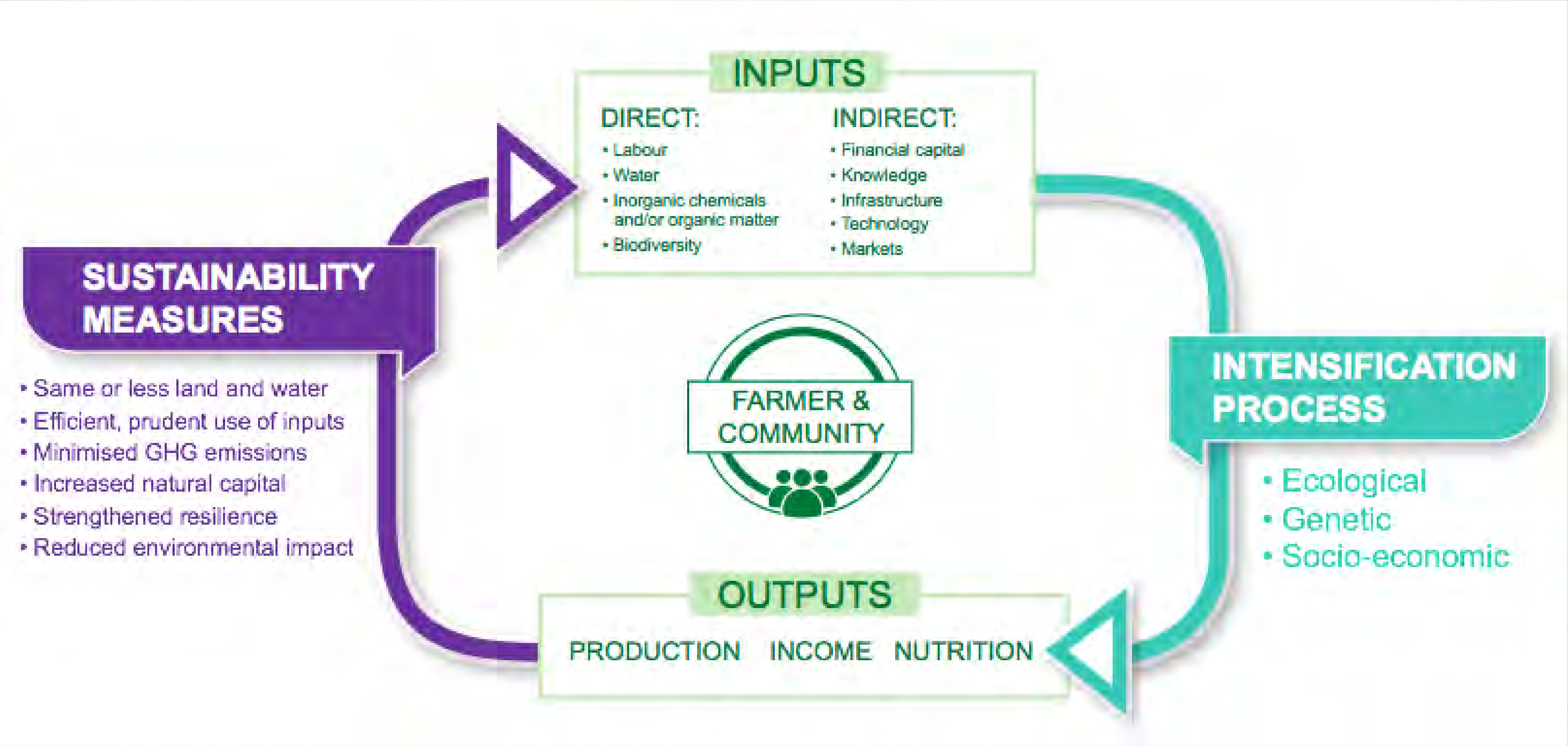
** NaHCO3-P unreliable at this soil pH

SAMPLE NUMBER	Nitrogen NO_3-N ppm	Sulfur SO_4-S ppm	Zinc Zn ppm	Manganese Mn ppm	Iron Fe ppm	Copper Cu ppm	Boron B ppm	Excess Lime Rating	Soluble Salts mmhos/cm	Chloride Cl ppm		Particle Size Analysis SAND %	SILT %	CLAY %	SOIL TEXTURE
NE000	21M	4L	1.8M	2L	132VH	1.2M	0.6M	L	0.2VL						
NW000	12L	5L	0.8L	1VL	118VH	1.5H	0.5L	L	0.1VL			60	26	13	SANDY LOAM
SW000	5L	4L	2.3M	1VL	141VH	1.4H	0.4L	L	0.1VL						

Mike Buttress, CPAg
A & L WESTERN LABORATORIES, INC

3. Plan a sustainable production system

Plan what to plant, when to plant, and who to market to. Try to be realistic in the first year.



4. Develop sustainable markets

Successful businesses are partnerships. Meet with restaurant owners, customers, chefs. Scout out your markets and develop relationships.

5. Track your income

- Develop a system to track your sales.
- Ideally, track sales of each type of item you sell (tomatoes, peppers, etc.) AND who the item is sold to (chef, farmers market, etc.)
- Use technology to help (QuickBooks)

Income...Find metrics to measure success...

Pick one simple metric to use across all of your products. For example:

- Dollar value per harvest container
- Value per row foot (important for smaller farms)
- Value you can harvest in one hour
  - SPIN farming website: spinfarming.com

6. Track your expenses

Ideally, keep track of expenses for each item you grow

Start at the beginning and keep track all the way to the end. Examples:

- seed costs
- costs to plant, weed, harvest (labor)
- costs to transport to market
- costs to rent booth space

Work as hard to trim expenses as you do to increase sales

- You can increase profits in only two ways: expanding sales or cutting expenses.
- Examine a printout of your expense ledger and ask, “How can we trim another 5% off this year?”

trim expenses...

With expense-cutting growth, savings are perennial. For example:

- If you can save $500/year on a cheaper compost from another supplier, over 10 years you’ll have saved $5000.
- If you can find a way to shave an average of just 20 minutes per day off your processing time, over ten years you will fee up 52,000 minutes--or 36 days!

then...spend time deciding what NOT to do

- After you have information on how different crops are performing, starting eliminating those that track low and scaling up those that perform well.
- Be ruthless. (Consider growing low-performers in a kitchen garden.)
- Set a bar. For example, eliminate crops that do not yield a set dollar value per hour spent harvesting and processing

7. Plan to get organized!

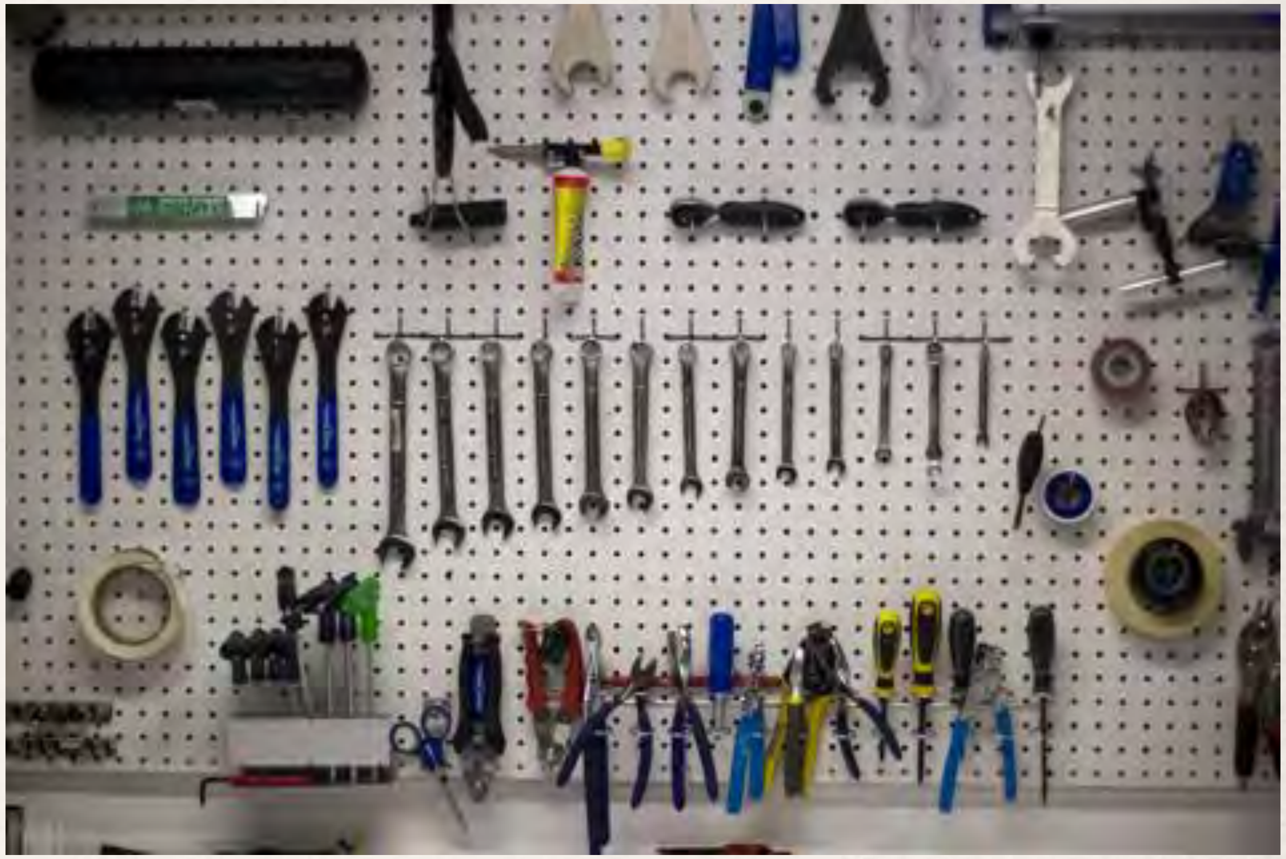
- An organized farm will be more profitable.

Get organized... Sort it

- Get rid of anything that is not absolutely necessary for your production and keep only what you need. When in doubt, get rid of it.
- Did you use it in the past 12 months? If not, the chances are good you won't use it in the next 12 months.

Get organized... Set it in Order

- Every tool should have a place. At any given time, it should be in its place or in the hand of a worker.
- Think of work stations instead of storage rooms.
- Don't stack, keep tools at eye level.
- Keep tools close to where they are used.



Get organized...Shine it

- Keep your workspaces clean - always.
- High gloss paint on floors and walls cleans well.
- Use plenty of light.
- Use a system for collecting recycling and waste. (Green totes and gray totes, for example)

Get organized...sustain your system!

- Make sure you and your crew USE your systems.
- In some factories, a worker is assigned at the end of each week to rate cleanliness!
- Set aside time each week for cleaning.
- Twice a year, “take it to zero”– remove everything from a space, clean thoroughly, and clean items as they are brought back in.

8. Create a smooth work flow

- Create a spaghetti diagram: Imaging watching your farm from overhead. Trace a line on paper whenever people move around. By the end of a typical harvest day, many farms would look like a plate of spaghetti.
- Smooth the noodles (eliminate unnecessary work):
  - keep tools close to where they will be used
  - harvest as market-ready as possible (eliminate moves)
    - example: harvest directly into totes going to market

9. “Level the Load”--spread out your work

- Spread out the weekly and yearly workload to avoid peaks
- Prepare Spring beds in Fall
- Harvest throughout the week
- Keep a winter project list
- Stretch out the season with greenhouses/season extension

10. And remember to give back!

- With your profits you can give back to your community by donating food and money to local food banks
- Give back to your land too: let it rest at least once/year by planting cover crops

Self-Check Review Questions

- What three areas of impact must a “sustainable” business take into account?
- What are different ways to measure profitability?
- How can farm work be spread out throughout the year?

Resources

- Specialty Crop Research Initiative: UW Madison
- http://ipcmRes.wisc.edu/scri/
- spinfarming.com
- milkwood.com

Composting

Learning Objectives

A. Understand the various roles of compost on a farm
B. Have basic understanding of the processes involved in decomposition
C. Learn how to make good compost pile and proper application method
D. Understand the definition and importance of quality “tilth” in soil

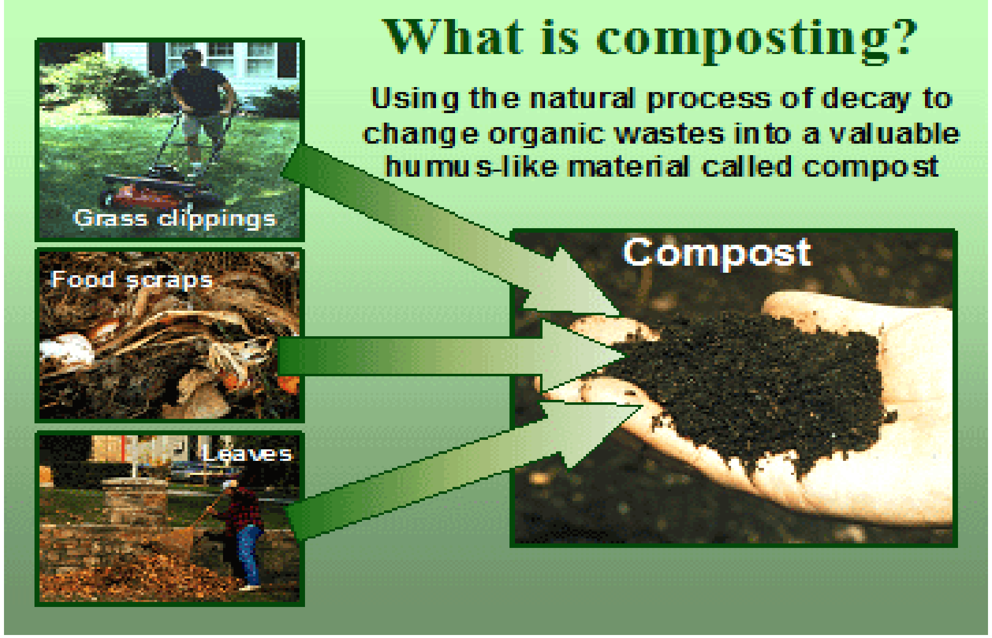
Two Types of Decomposition

Anaerobic decomposition is the breakdown of raw materials in the absence of oxygen and can be identified by a distinct foul smell and a generally "slimy" feel.

Aerobic decomposition is the breakdown of raw materials in which oxygen is present. This is the type of decomposition that is relevant for composting.

Definition of compost

Compost is the action and end result of decomposing organic materials in their raw form turning into vitally important soil amendment that improves the overall quality tilth of soil.



Compost can be produced through the act of decomposing plant matter as well as decomposing animal manure

Compost Ingredients

Watch a Video on Composting

Composting video

Compost bin building

Roles of Compost on a Farm

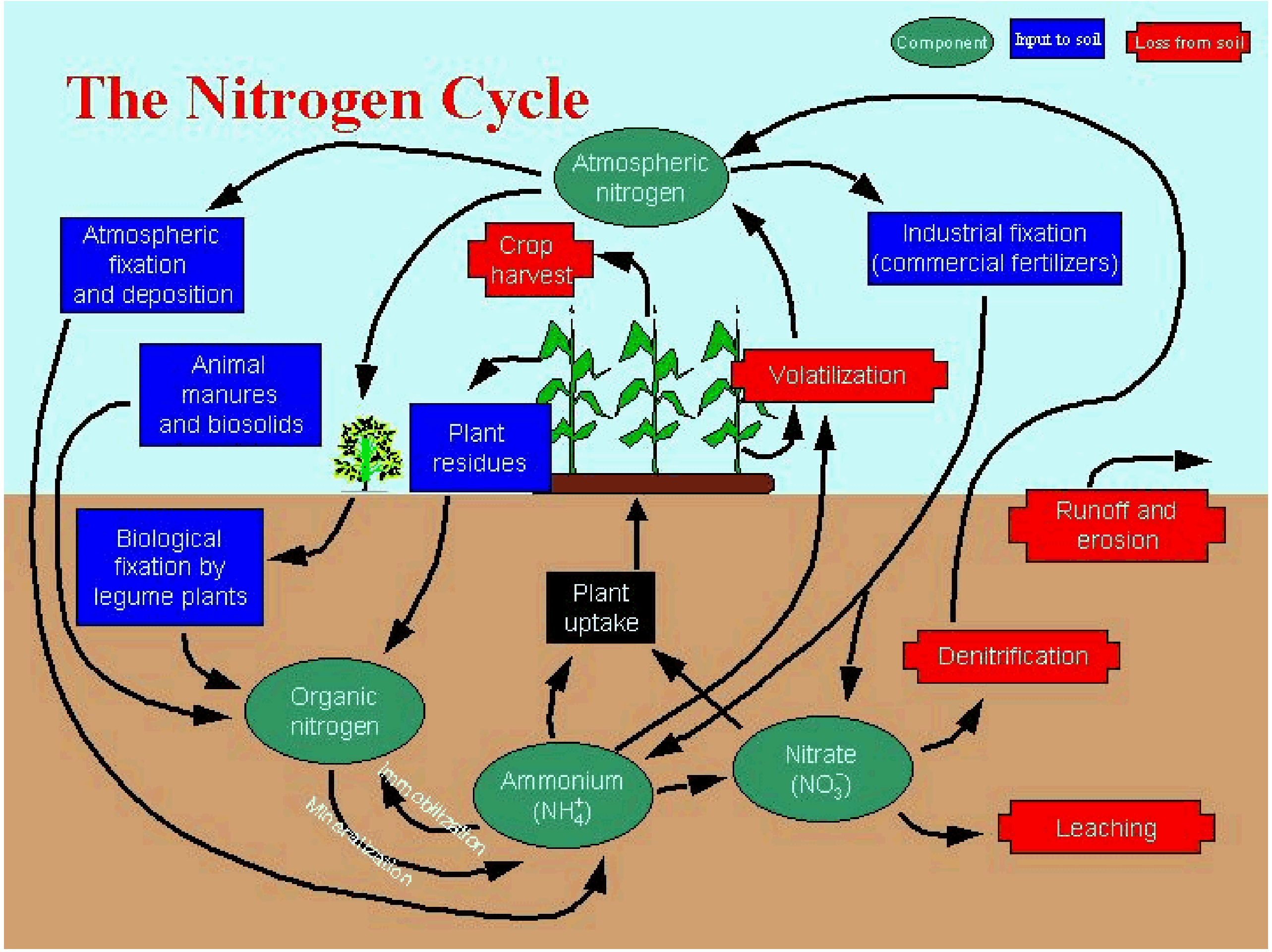
Recycles waste material on site

Humus

Adds large amounts of humus to soil

Humus is a brown or black complex variable material resulting from partial decomposition of plant or animal matter and forming the organic portion of soil

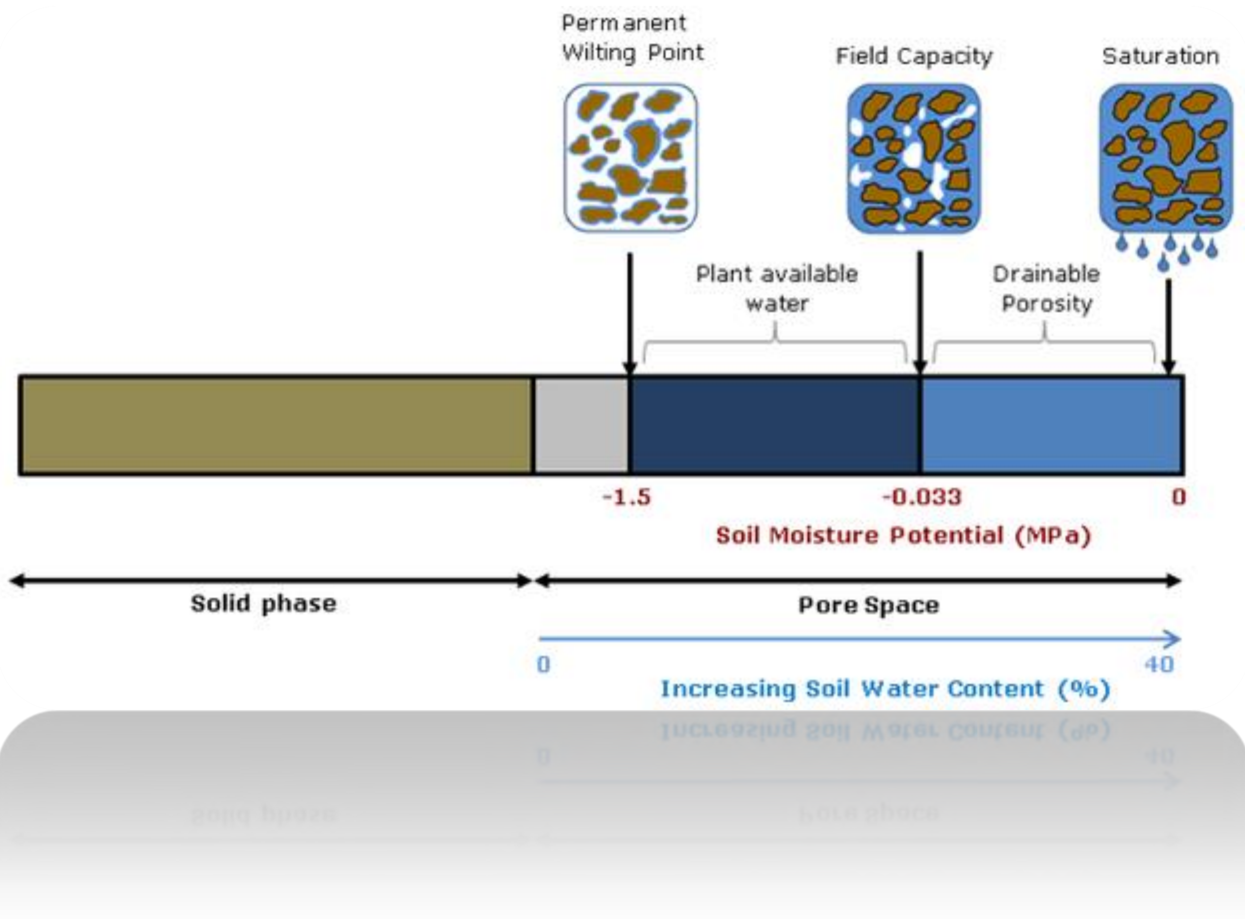
Increases soil fertility and stabilizes elements such as nitrogen



http://msucares.com/crops/soils/nitrogen.html

Hugely increases biological activity in the soil

Improves soil structure and ability to retain water or create percolation of water through soil



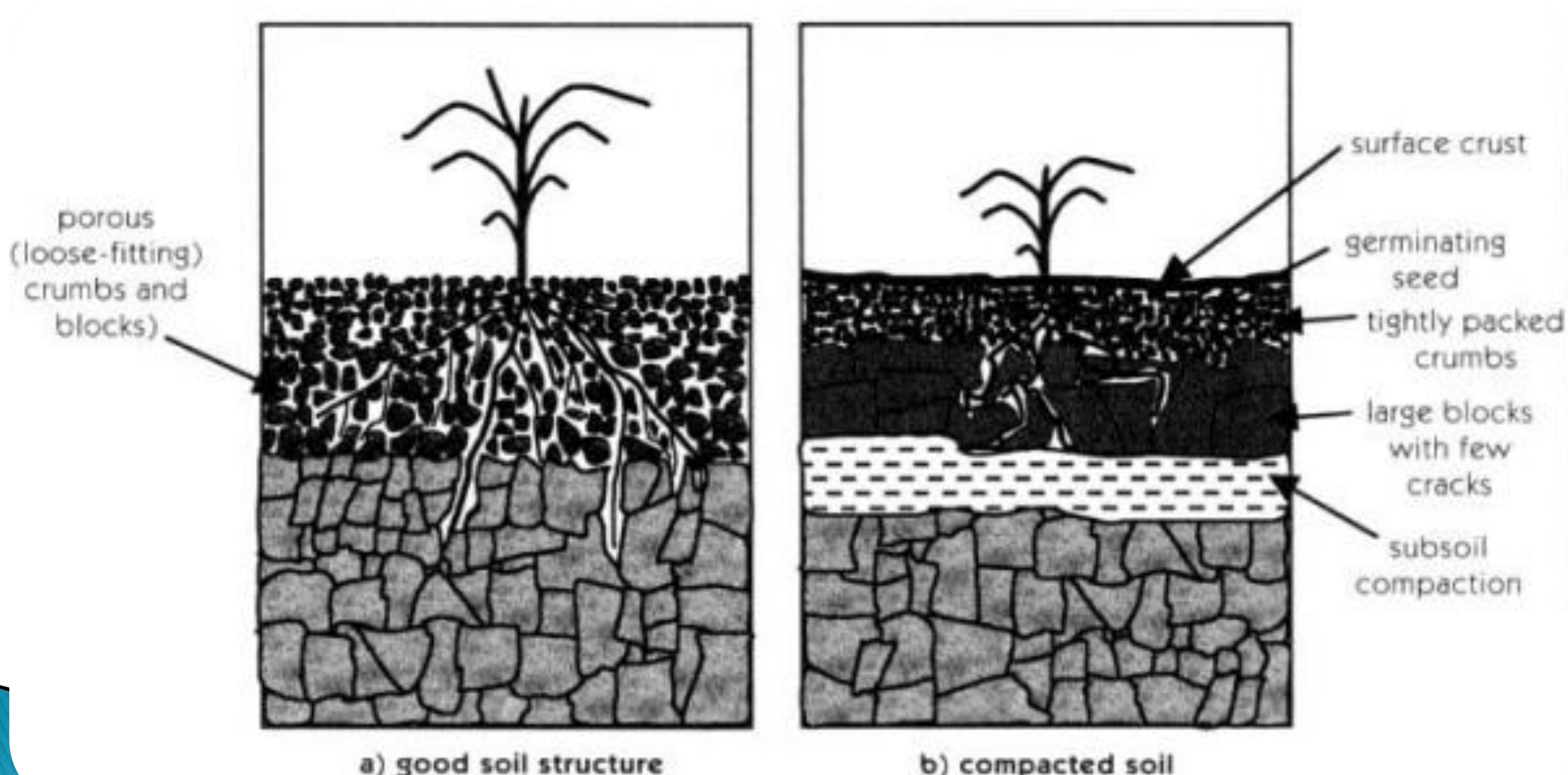
http://www.nature.com/scitable/knowledge/library/soil-water-dynamics-59718900

Creates outlet for potentially harmful excess of raw manure in animal based agriculture

Compost Improves Tilth

Tilth is the state of aggregation of soil and its condition for supporting plant growth.

This refers to the general overall suitable nature of soil's capacity to grow and sustain cultivated plant life. Compost is key to attaining a good soil structure and maximum fertility. It is the foundation of organic gardening.



Compost is a wonderful example of alchemy, changing waste material into vitally important materials

Processes in Composting

Decomposers 3 levels of consumers (organisms that feed on each other and the organic matter).

3rd Level
Macro
organisms

2nd Level
Meso organisms

1st Level
Micro organisms

A wide array of micro-organisms live in a compost pile.

Bacteria

Bacteria are the smallest living organisms and the most numerous in compost; they make up 80 to 90% of the billions of microorganisms typically found in a gram of compost. Bacteria are responsible for most of the decomposition and heat generation in compost. They are the most nutritionally diverse group of compost organisms, using a broad range of enzymes to chemically break down a variety of organic materials.

Fungi

Fungi include molds and yeasts, and collectively they are responsible for the decomposition of many complex plant polymers in soil and compost. In compost, fungi are important because they break down tough debris, enabling bacteria to continue the decomposition process once most of the cellulose has been exhausted.

Actinomycetes

Actinomycetes are organisms that resemble fungi but actually are filamentous bacteria. Like other bacteria, they lack nuclei, but they grow multicellular filaments like fungi. In composting they play an important role in degrading complex organics such as cellulose, lignin, chitin, and proteins.

http://compost.css.cornell.edu/microorg.html

Micro-organisms

Bacteria

Bacteria

Bacteria are micro-organisms that aid in the breakdown of carbonaceous material.

Micro-organism: Fungi

Performs more complex decomposition roles such as the breakdown of cellulose.

Fungal hyphae in healthy compost

Fungi binds free particulates together improving overall soil structure.

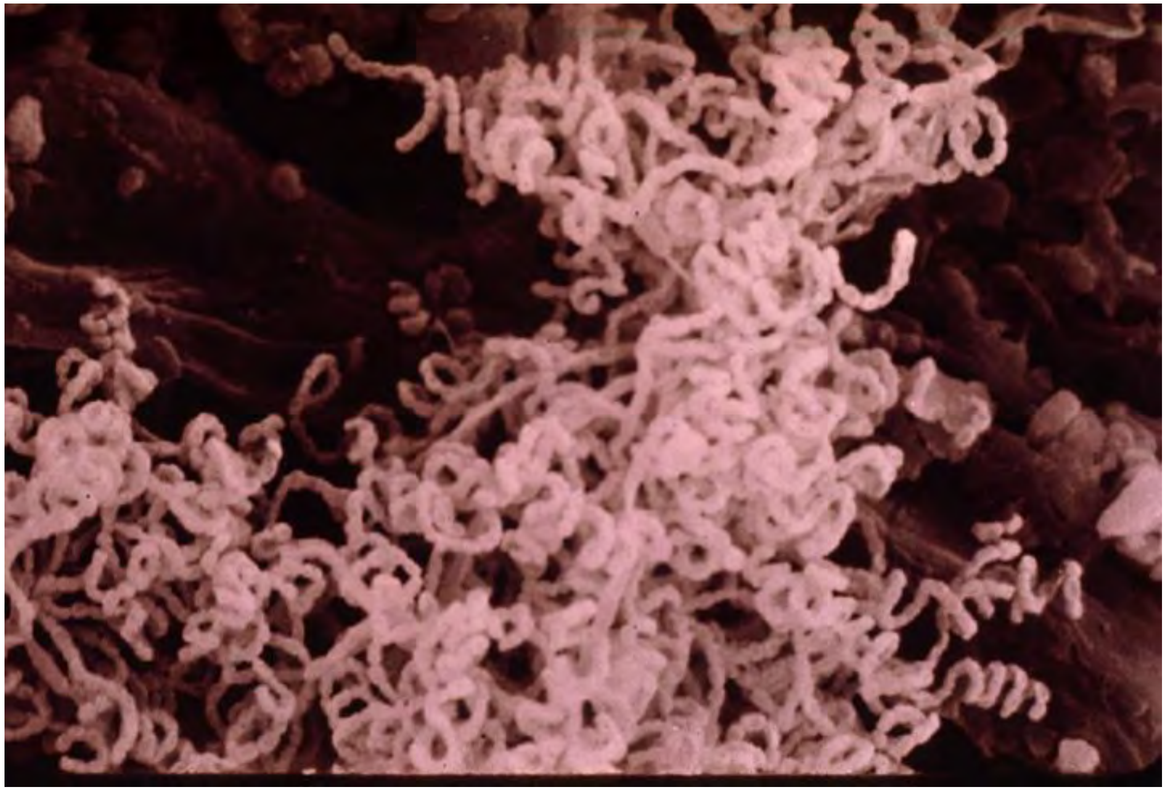
Fungi breaks down woody particulates in compost pile

Rotten tree trunk. The capacity of brown rot fungus to break down the cellulose in wood led to its selection for sequencing in 2007, with the goal of identifying the enzymes involved in the degradation process and using the information to improve cellulosic biofuels production. (Credit: © microimages / Fotolia)

http://www.sciencedaily.com/releases/2011/07/110714142139.htm

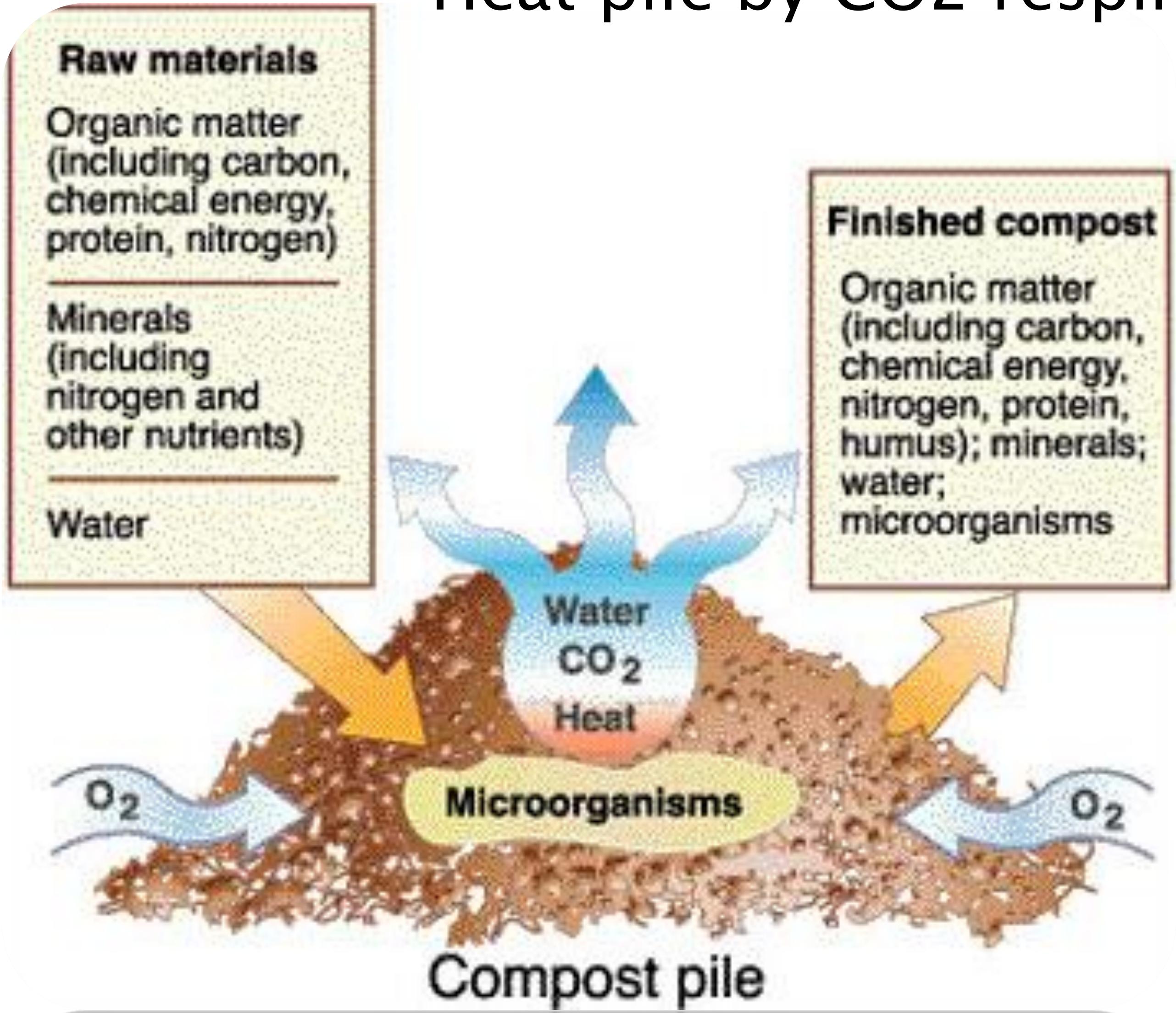
Micro-Organisms

Actinomycetes bind aggregates in pile through fungal like gray growths



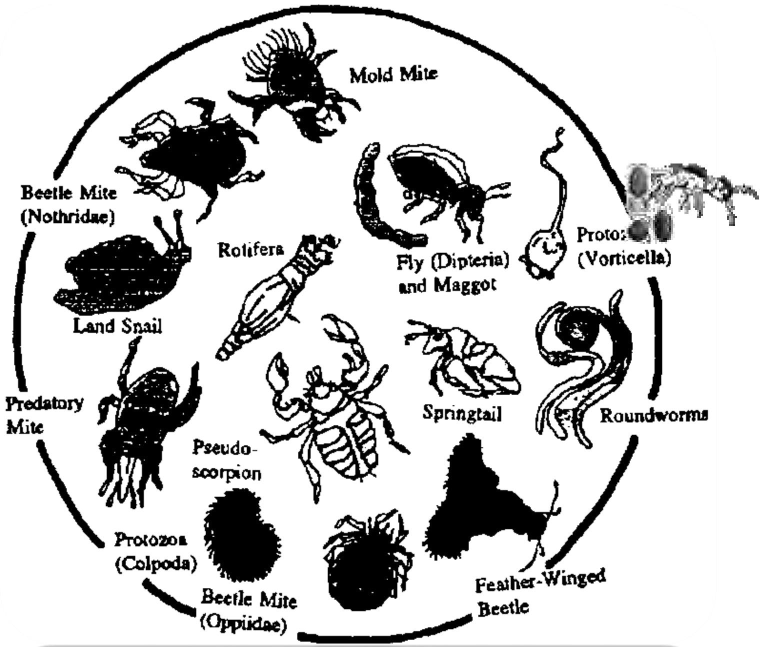
Actinomycetes, such as this Streptomyces, give soil its "earthy" smell

Heat pile by CO2 respiration



In the process of composting, microorganisms break down organic matter and produce carbon dioxide, water, heat, and humus.

2nd Level Consumers (Meso-organisms)



Nematodes or roundworms: They are the most abundant invertebrates in soil. Less than one millimeter in length, they prey on bacteria, protozoa, fungal spores and each other. Most nematodes in the soil are beneficial

Fermentation mites or mold mites: These transparent bodied creatures feed primarily on yeast in fermenting masses or organic debris. They can develop into seething masses over a fermenting surface such as a winery, but are not pests in compost.

Springtail: Along with nematodes & mites, they share numerical dominance among soil invertebrates. They feed on fungi, nematodes and small bits of organic detritus. They help control fungi.

http://collections.infocollections.org/ukedu/uk/d/Jii06be/3.5.html

3rd Level Consumers (Macro-organisms)

Most macro-organisms feed on earlier inhabitants of the compost pile. They're beneficial in their support of the food chain inside the compost pile. Worms are a very important part of the macro-organism family found in the compost pile.

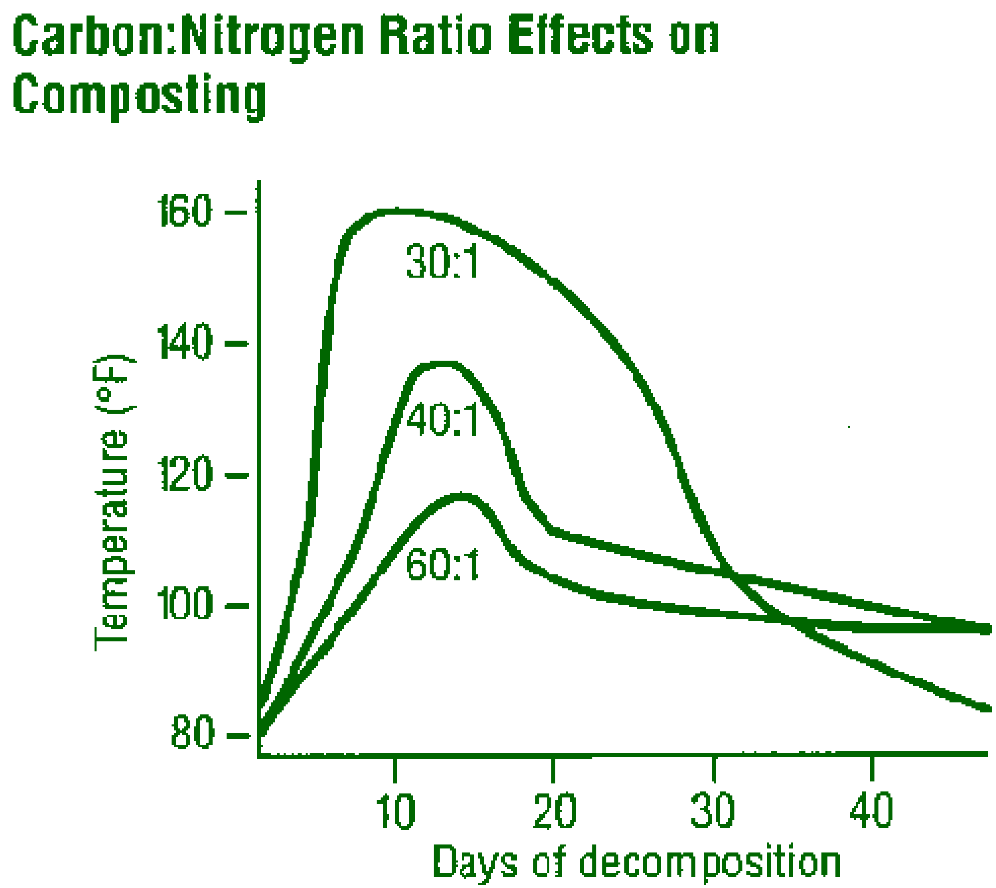
They produce castings, which contribute to the overall fertility of the soil

Worm castings are the end result of organic matter that has been processed by worms

They also aerate the compost mix, which introduces more oxygen, which in turn helps the pile finish faster and decompose more thoroughly.

Components of Good Compost

Carbon to nitrogen ratio is important to overall viability and health of pile. Initial ration should originally be 30:1 by weight



Here are some typical compost items and their carbon to nitrogen ratio. Brown compost ingredients have higher carbon(above 30:1), while green are higher in nitrogen(below 30:1). 30:1 is the desired ratio.

GREEN (Nitrogen)		BROWN (Carbon)	
Kitchen waste	25:1	Shredded newspaper	175:1
Coffee grounds	25:1	Twigs	700:1
Grass clippings	17:1	Shredded cardboard	350:1
Fresh Weeds	20:1	Leaves	60:1
Fruit waste	25-40:1	Pine needles	60-110:1

Manure C:N Ratios

Manure, farmyard (avg.)	14:1
Manure, chicken	7:1
Manure, cow	18:1
Manure, horse	25:1
Manure, human	6–10: 1
Manure, pig	8:1
Manure, poultry	15:1
Manure, sheep	8:1
Manure, steer	25.3:1

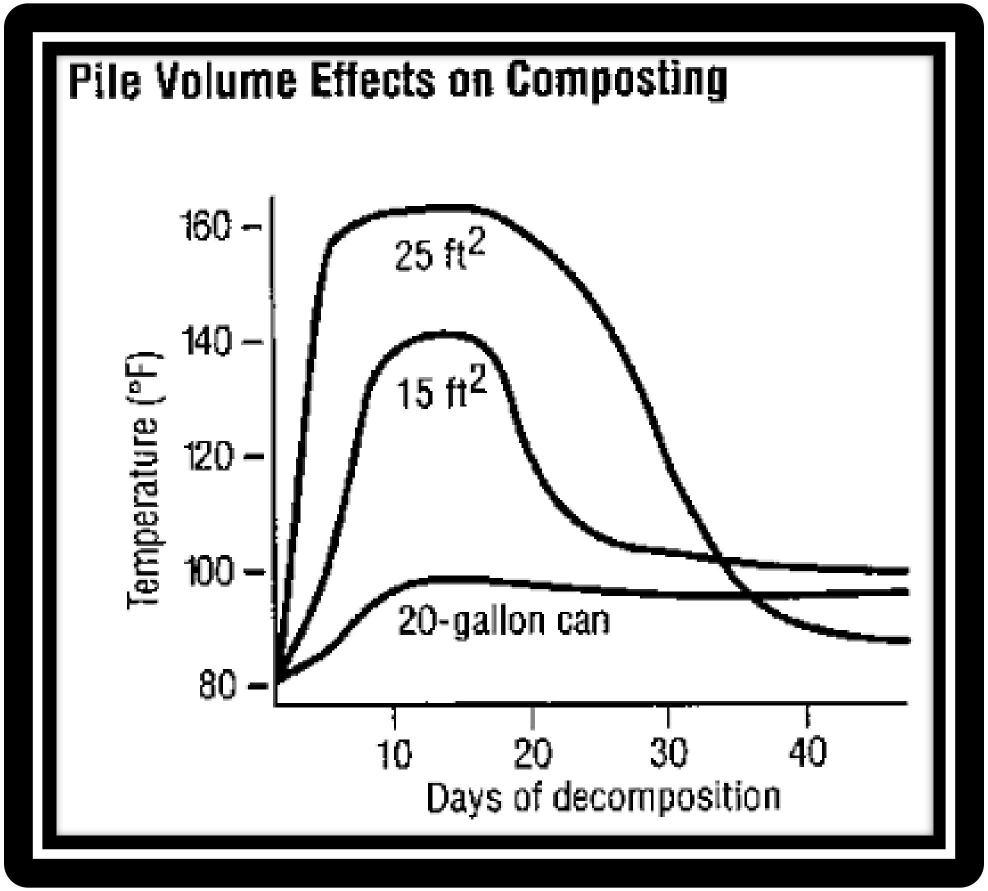
http://www.homecompostingmadeeasy.com/carbonnitrogenratio.html

http://www.weblife.org/humanure/chapter3_7.html

Moisture in pile should be equivalent to a moist sponge. A good rule of thumb should be the fist crumble test. One should be able to grab a fist full of compost and squeeze it into a ball that holds its form, but that crumbles under the slightest pressure.

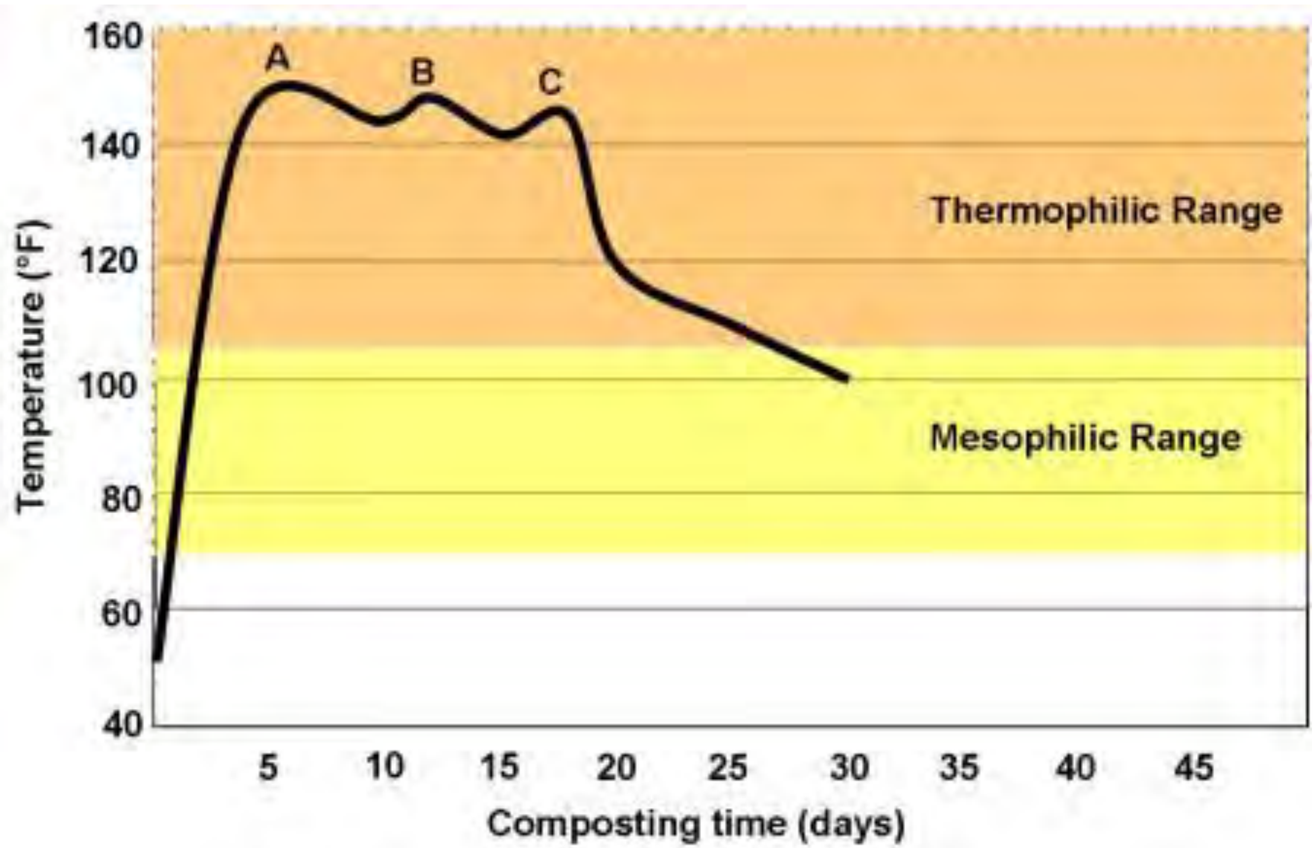
Video of Squeeze ball Test

Dimensions of the piles are important. Optimal size is 6’x6’x6’. This creates conditions that are most manageable and appropriate for a hot compost pile.



http://www.outsidepride.com/blog/tag/composting/

Optimal temperatures should be between 130 F to 150 F. Anything over 150F can begin to kill beneficial microbes.



A well-made compost pile will go through distinct three phases. First, it will enter into the mesophilic stage (68-104 degrees Fahrenheit). Second, it will enter into the thermophilic stage (105-150+ degrees Fahrenheit). Finally, the pile will enter into the maturation stage (not indicated on the graph).

http://www.compostjunkie.com/compost-thermometer.html

The compost pile should be covered in most situations. This will prevent excess water from leaching out good nutrients and possibly having negative runoff. It will also retain moisture in times of no rain and times of excessive heat, cutting down on the need to introduce water to the pile.

The compost pile should be turned regularly using one of many different available means. Turning the pile redistributes heat, biological activity, and moisture content. Turning the pile redistributes heat, biological activity, and moisture content. Turning a pile can finish compost up to ten times faster than letting a pile sit unturned.

[Video showing proper turning technique]

Application of Compost

- Five to seven tons of compost per acre is a generally acceptable rate of application for field dispersal
- Intensive garden situations can use up to 10 tons per acre

When developing a new garden or field, compost should be integrated into the top 18 inches of soil

For a developed field, compost integration should be no deeper than eight inches

Compost should be applied 3 times…

Compost should be applied in the spring prior to planting

midseason as an amendment side dress

and in fall prior to cover cropping

Assessment/Review

- Name several roles of compost on the farm.
- What types of organisms help the decomposition process?
- Why is it important to turn a compost pile on a regular basis?

Roles of Compost

- Recycles waste material on site
- Adds large amounts of humus to soil
- Increases soil fertility and stabilizes elements such as nitrogen
- Hugely increases biological activity in soil
- Improves soil structure and ability to retain water or create percolation of water

through soil

- Creates outlet for potentially harmful excess of raw manure in animal based

agriculture

- Compost is a wonderful example of alchemy, changing waste material into vitally important materials.

What types of organisms help the decomposition process?

- Bacteria
- Fungi
- Ace
- Meso & Macro-organisms

Why is it important to turn a compost pile on a regular basis?

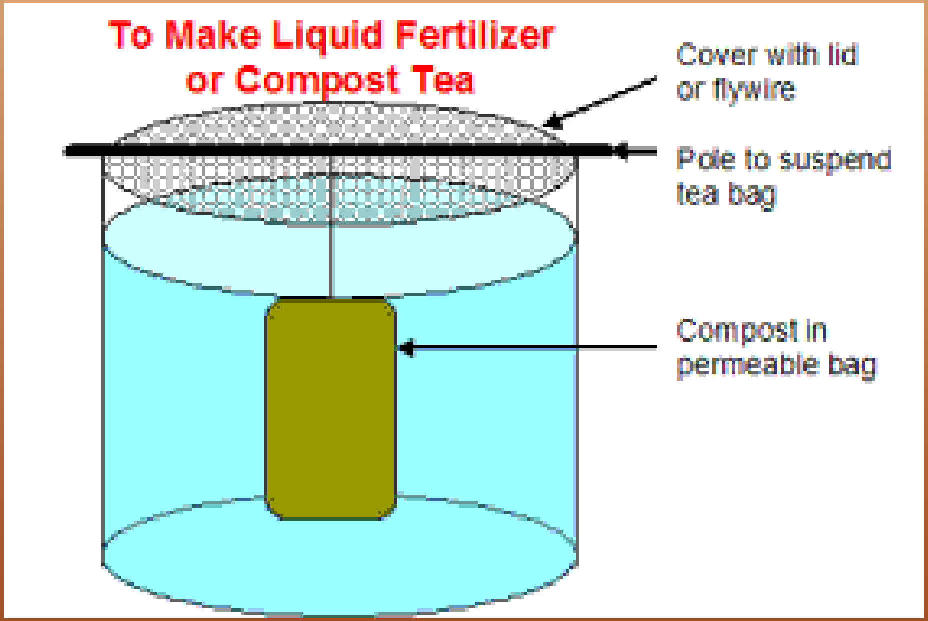
- Turning the pile redistributes heat, biological activity, and moisture content.
- Turning a pile can finish compost up to 10 times faster than letting a pile sit unturned.

Additional Viewing

- SOIL by Geoff Lawton
- http://www.geofflawton.com/sq/15449-geoff-lawton, Jeoff Lawton
- http://permaculturenews.org/2010/09/23/soils-dvd-available-october-2010/

Compost Tea

A guide to Earth friendly soil conditioning through using compost tea



Compost Tea

Learning Objectives

- The learner will gain a basic understanding of what compost tea is.
- The learner will learn what the benefits of compost tea are for the crops and soil.
- The learner will be shown how to make their own compost tea.
- The learner will be taught how to apply compost tea to their growing area, including the crops themselves.

Compost Tea

Introduction

Compost tea is a liquid extract of compost that contains nutrients and beneficial microorganisms.[1][2][3] Compost tea has the properties of being a fertilizer, pesticide and fungicide. It has the properties of fertilizer, in that, it adds nutrients the soil and plant. Unlike fertilizers, compost tea uses microorganisms to enrich the soil,[1][2] while creating a biofilm on the plants.[3][6] The biofilm is a thin coating of organic matter, including living organisms, that act as a pesticide and fungicide. It also provides future protection for the crops by creating a barrier of biomass between the crop and harmful organisms like insects, funguses and molds.[3][6]

Compost Tea

Introduction

Compost tea is simple to make and practical for all gardeners to use. Using compost tea is one of the safest ways to condition soil for optimal crop growth because there are no synthetic chemicals involved in making the compost tea.[1][2]

The benefits of using compost tea include:

- Increase in plant growth
- Provides nutrients to plants and soil
- Provides beneficial organisms to the growing area
- Helps to suppress diseases, while also preventing them
- Replaces toxic garden chemicals by reducing the need for additional fertilizers

http://www.youtube.com/watch?feature=player_detailpage&v=Uj4FL0u1wvg shows some of the benefits of using compost tea.

Compost Tea

Introduction

The most commonly used compost tea is called Aerated Compost Tea. [1][2][4] This type of tea uses air, either forced or mixed in, to promote aerobic bacteria growth. Aerobic bacteria are beneficial to the plants in creating nutrients in the soil, while providing a biofilm on the plants which protect them. In order for the biofilm to build upon the plant, some of the compost tea needs to be sprayed onto the plant as a foliar spray.[3][6]

A biofilm that is comprised of aerobic bacteria is beneficial to plants because it protects them from diseases like harmful fungus and mold.[3][5]

A biofilm that has aerobic bacteria in it is beneficial to us as consumers of the crop because aerobic bacteria will out-compete harmful anaerobic bacteria like E. coli.[5]

Compost Tea

The bucket fermentation method

There are two basic methods for making aerated compost tea; the bucket fermentation method and the bucket bubbler method.[4]
The bucket fermentation method is the oldest, and most simple method for making compost tea. This method has been used for several hundred years.[2]
The brew time for this kind of tea usually takes around 10 days.[4]

http://www.youtube.com/watch?feature=player_detailpage&v=GCbeALuAYsg&t=62 shows the bucket fermentation method for making compost tea.

Compost Tea

The bucket fermentation method

Materials needed

- ➢**<u>A large watertight *container*</u>** Choose a large container to brew the tea in. Many people choose to use a trash can or a 55 gallon container. It is possible to make tea in a container as small as a 5 gallon bucket,[1] with the result being less tea.
- ➢***<u>Compost</u>*** Choose a compost material that is well composted. Plant compost works the best because it has a high nutrient content. A mix of well composted manure can also be used. If composted manure is used in the compost tea, wait 90 to 120 days from the last application until harvesting due to potential pathogens like E. coli.[5] Compost from an earthworm bed or simply adding earthworm castings will increase the potency and nutrient value of the tea.[2][4]

Compost Tea

The bucket fermentation method

Materials needed

- ***A water permeable container*** Choose a sack or bag that lets water though it for placing the compost into. Some people prefer to use a bag, like a burlap sack, while others prefer to tie the compost into an unwanted sheet or pillowcase. Nylon and silk materials also work well.[4]
- ***Non-chlorinated water*** Use rainwater or water that has been de-chlorinated. Do not use tap water that has chlorine in it because it will kill the bacteria that we are trying to culture.[1][2][4] If the only source of water is tap water, allow the water to sit in an open container for several hours, preferably in the sunlight, as this will allow the chlorine to dissipate into the air faster. If you have bubblers, let them run in the bucket to help dechlorinate the water.[1]
- ***A big stick*** You will need a stick to stir the tea with. A broader stick with a larger surface area will help to circulate the water around the barrel better, though a broom handle or a wooden 2X4 will work fine.

Compost Tea

The bucket fermentation method

Optional materials

- ***A short piece of rope and a plank longer than the width of the barrel*** It is a good idea to suspend the water-permeable bag of compost onto a plank that is laid on top of the barrel. This allows for the bag of compost to have the maximum surface contact with the water. If not suspended, the bag of compost can sink to the bottom of the barrel.

- ***Additives*** There are some additives that will increase the amount of biology and rate of biological growth in the teas. A common additive is unsulfured molasses because the sugar is used by bacteria for food and it speeds up the bacteria growth.[1][2] Some growers also add: yeast extract, oatmeal, fish-based products, kelp and green plant tissue.[4]

Compost Tea

The bucket fermentation method

Step 1) Fill the watertight container half way with non-chlorinated water.

Step 2) Fill the water permeable container with compost and any solid additives , like oatmeal, then tie the end.

Step 3) Suspend the compost bag with a rope and plank so the compost bag is able to be completely submerged without lying on the bottom of the barrel.

Step 4) Add any liquid additives that you have to the water and mix them in. Many people add one ounce of unsulfured molasses for every seven gallons of water.

Step 5) Stir the tea at least once in the morning, and once at night. Keep in mind; the more the compost tea is stirred, the more oxygen gets into the tea’s water. This is very beneficial to the kind of bacteria, fungus and other biological life that we are trying to grow in the tea.

Compost Tea

The bucket bubbler method

The bubbler bucket method is very similar to the bucket fermentation method, in brewing the tea. The bubbler bucket method is more successful in creating high quality teas because this method incorporates more oxygen into the tea while it is brewing.

http://www.youtube.com/watch?feature=player_detailpage&v=-0en00_CSM4 shows how to make and use compost tea from the bubbler bucket method.

Compost Tea

The bucket bubbler method

Materials needed and process

The materials that are needed for the bucket bubbler method are the same as the bucket fermentation method, in addition to bubblers. The bubblers serve as an extra means to get oxygen into the water, rather than just stirring in air.[1][2] The most common bubblers that growers use for compost tea are the same bubblers that are used in fish aquariums. There should be about one bubbler for every five to seven gallons of water.[1] It is necessary to stir the compost tea frequently throughout a day's period, because it helps separate the living organisms from the compost material.[4][5] Most teas made from the bubbler bucket method are brewed for 24 to 36 hours.[4] Stirring frequently, or using a more decomposed compost, will decrease the amount of time necessary for the compost tea to brew.[4][5]

These bubblers are commonly called air stones. Using air stones is a good idea because they and they do not clog easily. Generally, medium to large sized bubbles are desired when making compost tea.[5]

Compost Tea

Other considerations in making compost tea

➢ ***<u>Good compost tea smells good</u>*** *A* good quality compost tea is characterized by an earthy, sweet smell; it should never stink.[1][2] If the compost tea has a foul smell to it, that means the tea did not get enough oxygen during the brewing process. It should not be used because it has alcohol and anaerobic bacteria in it, which are harmful to plants.[1][2][4]

➢ ***<u>Ratio of compost to water</u>*** There are no specific ratios of water to compost. Rather, water is more of a solvent and diluter for the compost tea.[2][4] Very little water will result in a tea that is very concentrated.[1][2] An non-concentrated tea will often be found with a ratio of about 1 part compost to 5 parts water.[1]

➢ ***<u>Characteristics of the "tea bag"</u>*** The material for the bag should not have chemicals in it, like sheet sprays. If the tea is intended for a drip irrigation system or a sprayer, the tea may particles in it that can plug the nozzles.[4] To avoid this problem, use a very fine mesh like nylon, silk or tight-woven cotton cloth for the tea bag. The tea can be strained after brewing with these cloth materials as well. Do not use multi-layer cloth or felt because hyphae, one of the good biological organisms, get trapped in the fabric.[5]

Compost Tea

Other considerations in making compost tea

- ***Temperature*** The compost tea should be brewed with water that is close in temperature to the ground temperature. If it is very hot outside, setting the barrel in the shade can help keep the temperature down. The biological life in the tea can be harmed if the tea gets too hot.[4]
- ***Pressurized equipment*** If the compost tea is going to be spread by pressurized sprayers, make sure that equipment is not pressurized to the point where it could kill biological organisms. Some irrigating equipment for large fields use very high pressures. Usually the manufacturers of large irrigation equipment will state whether or not the pressure is sufficient to kill living organisms.[5] Most microbes will die at pressures near 150 pounds per square inch.[6]

Most hand-pump sprayers and spray bottles do not have enough pressure to kill living organisms.

Compost Tea

Other considerations in making compost tea

- ***Dilution*** Some growers who make and use compost tea frequently will dilute their tea. The reason for dilution is that compost tea can be too nutrient rich for the plant's current needs. Always use non-chlorinated water to dilute compost tea. Non-diluted tea can be given to plants about once every two weeks.[1] To dilute compost tea, mix one part tea with one part water.[1][2] Use diluted compost tea generously.
- ***Timing for application*** The compost tea should never sit for several hours after the bubblers get turned off. Once the bubblers are turned off, the aerobic bacteria begin to die as they use up the oxygen in the tea mixture. It is a good idea to apply the tea within four hours of shutting off the bubblers.[1][2] Another timing factor that should be considered is the time of day. Foliar sprays should be applied in the early morning or at dusk, because of the ultraviolet rays. The ultraviolet rays are harmful to the beneficial organisms in the tea. [2] In a foliar spray, the beneficial organisms are very exposed to ultraviolet light that shines through the mist.

Compost Tea

Applying compost tea to the crops and growing area

Compost tea has the properties of being a soil conditioner through building a biologically diverse food web in the soil.[2][5] Compost tea also creates a biofilm on the plants when the tea is given to the plants as a foliar spray.[3][6] This biofilm helps prevent water loss of the plants by preventing water from evaporating out of the leaves.[3][5][6] Many plants have the ability to absorb some nutrients through their leaves,[5] which make plants able to immediately benefit from a foliar application of compost tea. For these reasons, compost tea should by applied as a foliar spray and also used to water the plants near the root zone.[1][2][6]

Compost Tea

Applying compost tea to the crops and growing area

Applying compost tea as a foliar spray

Foliar spraying, or sometimes called foliar feeding, is a term that describes a method of applying a material to the foliage of a plant. There are two basic methods for applying compost tea as a foliar spray.

The first method is relatively simple. It uses a watering can with a nozzle to sprinkle the compost tea over the plant.

The second method of applying a foliar spray uses a spray bottle or a pressurized container with a spray nozzle. The advantage of using a spray nozzle is that the grower can spray the underside of the leaves. This is important because the biofilm is beneficial to the entire plant.[3][5][6] Additional compost tea is usually given to the plant's root zone after a foliar spray is used.[1][2][4]

Compost Tea

Follow-up after making compost tea

After making compost tea, there will be a lot of solid materials from the compost that are still useful. Many growers will use this compost as mulch to place around their plants. Other growers will put the brewed compost solids back into their compost pile because the brewed compost solids have newly cultured life in it that will benefit the compost pile.

The last task is to clean the equipment that was used to make the compost tea, unless another batch is going to be made immediately afterward. The reason for a proper cleaning is that we do not want to have anaerobic bacteria, harmful fungus or mold growing in or on the equipment itself.[7]

Compost Tea

Follow-up after making compost tea

Cleaning the equipment

The first step in cleaning the equipment that was used to make compost tea is to power wash the barrel. This can also be done with a garden hose and nozzle. After power washing the barrel, it should be hand cleaned with a solution of 10% bleach to 90% water. An alternative to bleach is a solution of 2 to 5 percent hydrogen peroxide.[7] The bubbler tubes and air stones should be soaked in the cleaning solution and, if reusable, the water permeable bag should be power washed and then soaked in the cleaning solution as well.[7] Allow all of the equipment to dry completely before storing them in a dry place.

Compost Tea

Review questions

- What are some of the ways that compost tea can be made?
- What are some of the potential benefits for the crops when the crops are given compost tea?
- How should compost tea be applied to the crop being grown?
- What are some of the benefits of giving compost tea as a foliar feeding?
- What does a quality compost tea smell like? What about a poor quality tea?
- What is needed for aerobic bacteria to survive?
- How should the equipment for making compost tea be cleaned after compost tea is made?

Compost Tea

References

[1] *Compost tea*. (2007). Retrieved from Pennsylvania Department of Environmental Protection: http://www.dep.state.pa.us/dep/deputate/airwaste/wm/recycle/Tea/tea1.htm

[2] *Compost tea*. (2013). Retrieved from Oregon State University Extension Service: http://extension.oregonstate.edu/douglas/mg/dcmg/aerated-compost-tea

[7] Ingham, E. (2013). *Compost tea brewers; Keeping it clean*. Retrieved from Heart Spring: http://heartspring.net/compost_tea_brewer_cleaning.html

[4] *Making compost tea*. (2012). Retrieved from CalRecycle: http://www.calrecycle.ca.gov/Organics/CompostMulch/CompostTea/Making.htm

Compost Tea

References

[5] *Making compost tea and extracts*. (2012). Retrieved from The Earth Project: http://www.theearthproject.org/id53.html

[3] Morris, C. E., Monier, J. M., & Jacques, M. A. (1997). Observing microbial biofilms on leaf surfaces and isolation of culturable microbes. *Applied and Environmental Microbiology*, 1570-1576.

[6] Schmidt, P. (2010). *Foliar applications of compost tea.* Retrieved from CompostJunkie: http://www.compostjunkie.com/support-files/foliar_applications_ct.pdf

Cover Crops

Objectives

Student will learn...

- advantages and uses of cover crops in organic and permaculture farming
- how to choose best cover crops to use in different applications
- different application methods
- different methods of incorporation

Definitions

- Cover Crop: any crop seeded primarily for the purpose of improving or holding soil
- Cash crop: a crop seeded primarily for sale
- Top Soil: the top layer of soil, usually containing the highest proportion of organic matter and nutrients
- Organic matter: nutrient-rich, biologically-derived soil ingredient

Advantages and uses of cover crops

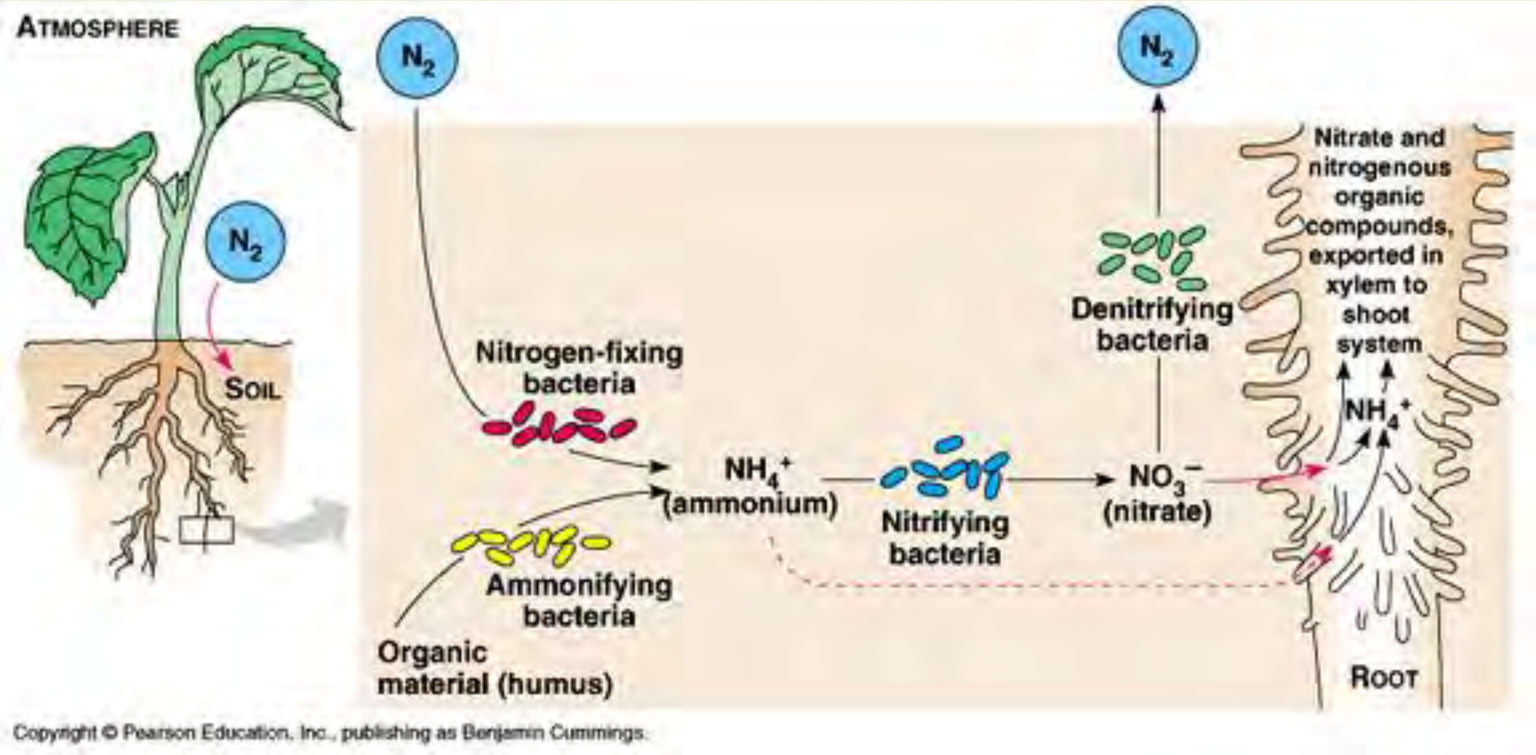
- Cover crops are an excellent way to hold and stabilize topsoil when land is not in use

advantages...

- Cover crops with deep roots are frequently used to loosen hard soils

advantages...

- legume-family cover crops can "fix" nitrogen, i.e. make soil-bound nitrogen more available to plants



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advantages...

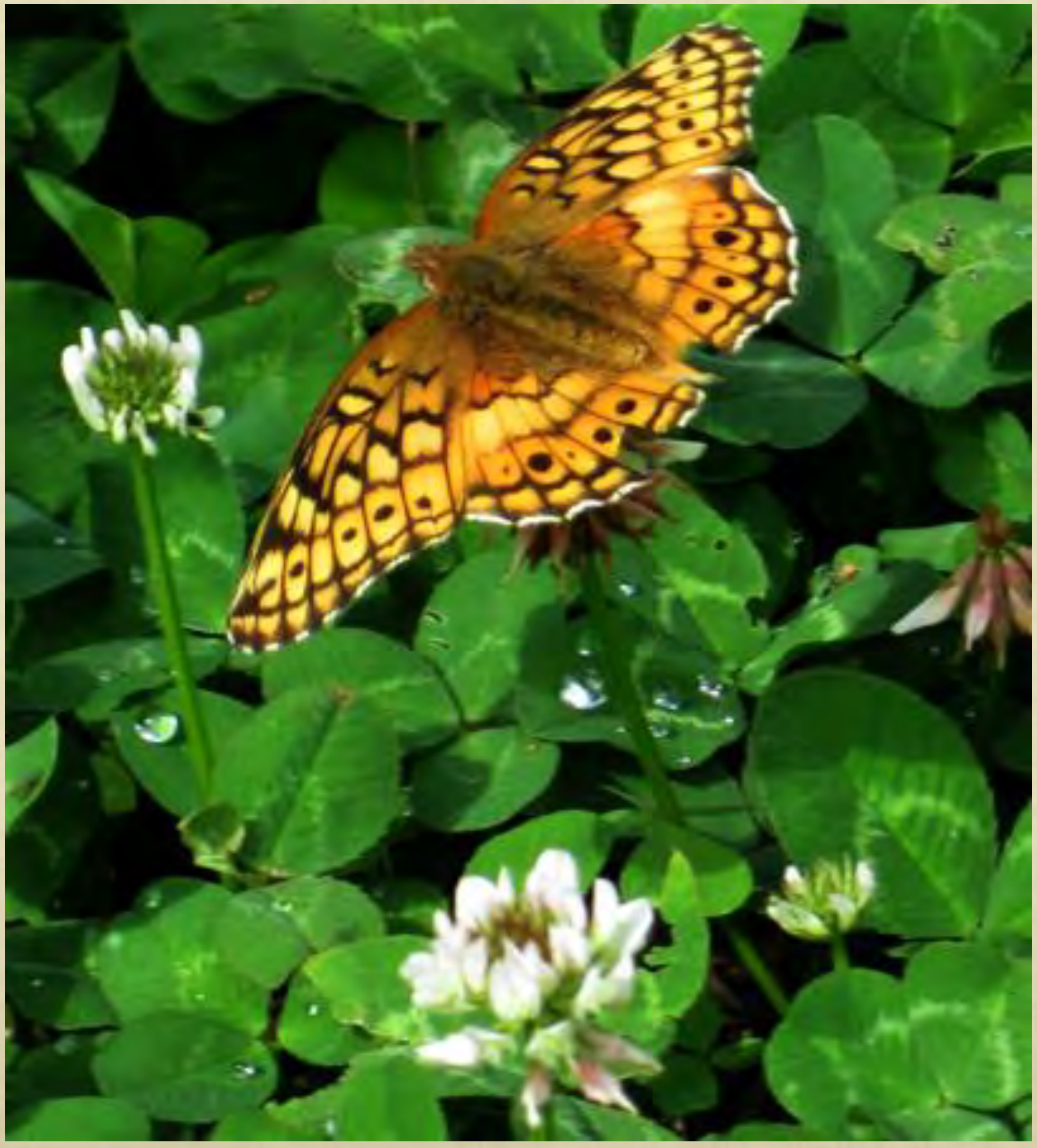
- Once tilled-in, cover crops add organic matter and build soil fertility

advantages...

- Cover crops are sometimes used as a weed barrier between rows of crops

Advantages...

- Some cover crops can attract beneficial insects



Select cover crops' uses

Cover Crop Chart

Key to Symbols: = Excellent = Very Good = Good = Fair = Poor

	Species	When To Plant	Min Germ Temp	Seeding Depth Inches	Seed Per 1000 sq ft	Pounds Of Seed Per Acre	Hardiness To Zone	Legume N Source	Nitrogen Recycler	Chokes Out Weeds	Pounds Organic Matter Per Acre	Forage Or Hay	Attracts Beneficial Insects	Erosion Control	Nematode/ Symphylan Control	Soil Builder
Legumes	Summer Alfalfa	Late Summer	45°F	¼-½	½ lb	12-15	5	Very Good	Good	Good	2000-4000	Excellent	Good	Very Good	Poor	Very Good
	Hairy Vetch	Early Autumn, Spring, Summer	55°F	1½-2½	1 lb	25-40	4	Excellent	Fair	Very Good	2300-5000	Good	Excellent	Good	Fair	Very Good
	Common Vetch	Early Autumn, Spring, Summer	55°F	1½-2½	1 lb	25-40	4	Excellent	Fair	Very Good	2300-5000	Good	Very Good	Good	Fair	Very Good
	Austrian Field Peas	Autumn	40°F	1-3	2-4 lbs	75	7	Excellent	Fair	Good	4000-5000	Very Good	Very Good	Very Good	Good	Very Good
	Crimson Clover	Anytime	45°F	¼-½	1-2 lbs	30-40	7	Very Good	Good	Very Good	3500-5500	Excellent	Very Good	Very Good	Fair	Very Good
	Mammoth Red Clover	Early Autumn	40°F	¼-½	½ lb	20	4	Very Good	Fair	Very Good	4000-6000	Good	Very Good	Very Good	Fair	Very Good
	New Zealand White Clover	Spring Autumn	40°F	¼-½	¼ lb	6-10	4	Excellent	Fair	Very Good	2000-6000	Excellent	Good	Very Good	Poor	Very Good
	Berseem Clover	Early Autumn	42°F	¼-½	1 lb	15-20	8	Excellent	Very Good	Very Good	6000-10,000	Excellent	Good	Very Good	Poor	Very Good
	Medic Mix	Autumn-early Spring	45°F	¼-½	1 lb	15	8	Good	Fair	Very Good	1500-4000	Very Good	Very Good	Good	Good	Good
	Fava Beans	Autumn	55°F	1-3	5 lbs	200	7	Very Good	Fair	Good	3500-7000	Good	Very Good	Good	Poor	Very Good
Brassicas	Mustard	Early Autumn & Spring	40°F	¼-¾	¼ lb	6-10	7		Good	Very Good	5000-12,000	Good	Good	Very Good	Very Good	Very Good
	Radish	Autumn	45°F	¼-½	½ lb	10-12	8		Excellent	Excellent	4000-7000	Good	Good	Very Good	Very Good	Very Good
	Turnips	Autumn	45°F	¼-½	¼ lb	4-6	6		Very Good	Very Good	8000-12,000	Good	Good	Poor	Poor	Very Good
Cereal Grains & Grasses	Annual Rye Grass	Early Autumn	40°F	0-½	1 lb	20-30	5		Very Good	Excellent	2000-9000	Very Good	Fair	Very Good	Good	Very Good
	Winter Rye Grain	Autumn	34°F	½-2	4-5 lbs	50-125	3		Excellent	Excellent	3000-10,000	Good	Fair	Excellent	Good	Excellent
	Winter Barley	Late Summer to Autumn	37°F	¾-2	2-3 lbs	75-125	7		Very Good	Very Good	2000-10,000	Very Good	Good	Excellent	Fair	Very Good
	Winter Triticale	Autumn	34°F	1½-2	2-3 lbs	60-120	6		Very Good	Very Good	6000-8000	Very Good	Fair	Very Good	Poor	Very Good
	Winter Wheat	Autumn	38°F	½-1½	3-4 lbs	70-150	4		Very Good	Excellent	3000-8000	Very Good	Fair	Very Good	Fair	Very Good
	Winter Oats	Autumn	38°F	¾-2	1-2 lbs	50	8		Very Good	Excellent	2000-10,000	Very Good	Poor	Very Good	Poor	Good
	Buckwheat	After last frost	48°F	½-1½	2-3 lbs	50	Not Frost Tolerant		Fair	Excellent	2000-4000	Poor	Excellent	Fair	Fair	Good

Territorial Seed Company - 2013

For holding a soil...

Consider:

How long until you plan to use the soil again for cash crop?

- for short-term (less than 3 months), use buckwheat, oats, tillage radish, sudangrass, turnips, wheat
- for medium-term (3-6 months), use red clover, winter rye, vetch
- for long-term (6 months-several years), use clovers, forage grasses

to loosen hard soils...

- Choose a cover crop with deep tap roots: tillage radish, turnips, clovers
- for permaculture farms, these crops can replace to work of deep tillage machines

To fix nitrogren...

- Choose a cover crop in the legume family: summer alfalfa, clovers, field peas
- Note: these can be used alone or mixed with other crops crops, for example:
  - mix red clover with winter rye to hold a field over winter

To add organic matter...

- Choose a cover crop with high bio-mass, such as sorghum-sudangrass, winter rye, crimson clover
- considerations: the larger a crop, the more difficult it is to incorporate

As a weed barrier...

- In open fields... Oats, vetch, clover
- For between rows of crops... undersow with clover, or ryegrass (could require mowing)

To attract beneficial insects

- Choose cover crops with colorful flowers: crimson clover, vetch, turnips

Cover Crop Application... Small Scale

http://youtu.be/uTlhEgUeUK4

For permaculture and small-scale (less than 1/2 acre) farms, cover crop can be spread easily by hand. Use a quick wrist flick to spread evenly, then rake in...similar to sowing seed for a lawn

Application...medium-size farm

- For larger plots, a hand-held broadcast seed spreader helps spread seed evenly
- Then cultipack seeds to ensure good soil-to-seed contact

http://youtu.be/jjqiN2mwchY

Application... larger farms

- Option 1: mount 3-point a drop spreader behind tractor, then cultipack seeds
- Option 2: Purchase or rent a commercial seed drill

http://youtu.be/quEp60g29Dg

How to incorporate your cover crop...small scale

http://youtu.be/0mqFl86BOck

- Option 1: Use a hand scythe to cut the crop. Then use a shovel to "plow" it in.
- Option 2: Use a walk-behind tiller to till in the crop (works best on smaller crops)

How to incorporate cover crop… larger farms

- Option 1: Use a tractor-mounted tiller to till in the cover crop

- Option 2: Use a flair mower to chop the crop into small pieces, then plow under

http://youtu.be/lY7g3CBwnZA

When to plant cover crops... Spring

- Good cover crops for Spring planting...peas, oats, hairy vetch, clover, radish, turnips

When to plant cover crops... Summer

- For summer cover crops...buckwheat, sorghum-sudangrass

When to plant cover crops... Fall/Winter

- Fall/winter cover crops... clovers, winter rye, peas, vetch, radish, turnips

When to incorporate

- “2/3 bloom”... for maximum organic matter, incorporate when 2/3 of the flowers have appeared
- Don’t wait too long! the cover crop will develop seeds and become a weed
- Don’t till too soon! the cover will not contribute a maximum amount of organic matter

Cover Crop Combinations...Spring

- Combining cover crops can give farmers the benefit of multiple crops in one season
- Spring crops to combine: field peas, oats, hairy vetch, clovers

Cover Crop Combinations...Fall

- Crops to combine for a fall sowing: winter rye, field peas, ryegrass, crimson clover, hairy vetch

Self-Review Questions

- What farming objectives can be met with cover crops?
- What cover crops are best for loosening soil?
- What benefits do clover and vetch offer?

Resources

- johnnyseeds.com
- covercropsolutions.com
- www.organicgardening.com/learn-and-grow/cover-crop-basics

Crop Rotation

A smart way to build and maintain healthy soil

Crop Rotation: Step #1 for Soil Quality

How this crop rotation module is organized

A. Intro: Learning Objectives, Definitions, and History
B. Basic science behind crop rotation
C. The 6 major benefits and how they work:
   1. Naturally fertilizes
   2. Improves soil structure
   3. Controls weeds, diseases, and harmful insects
   4. Increases microbiology; bacteria and insects
   5. Preserves the environment
   6. Decreases costs; increases revenue of farming
D. Detailed science of plants' effects on soil and ecosystem
E. Models for crop rotation
F. Assessment/Review

Learning Objectives

- Understand various benefits of a system of crop rotation.
- Examine two popular rotational designs.

Definition of Crop Rotation

Crop rotation is a system of moving crops. The goal is not to grow the same thing in the same place in consecutive years.

Just as our diet needs variety, so does the soil.

Other terms to know for crop rotation

- <u>Nitrogen Fixers</u>- plants, such as legumes, that add nitrogen to soil
- <u>Continuous Crop</u>- single-plant crops that are not rotated and rely on artificial fertilizers and pesticides
- <u>Ecological Sustainability</u>- Biological systems' capacity to endure and remain diverse and productive over time
- <u>Heavy Feeders</u>- plants such as corn and tomatoes, that require a lot of nutrients from the soil
- <u>Microorganisms/Soil Food Web</u>- life in the soil that facilitate nutrient cycling from the nutrient reservoir to plant roots See (Soil Science Module)

Historic Precedence

Ancient Greek, Egyptian, and Chinese farmers used Crop Rotation.

It's only been since the 1950's that large, continuous crop farming has been attempted. Monoculture fails to work as well as rotated crops and requires harmful chemical pesticides and fertilizers.

Crop rotation has proven itself in a 100+ year study in the U.S. and is widely recognized as a cornerstone of good agricultural practice.

See Old Rotation for the proof.

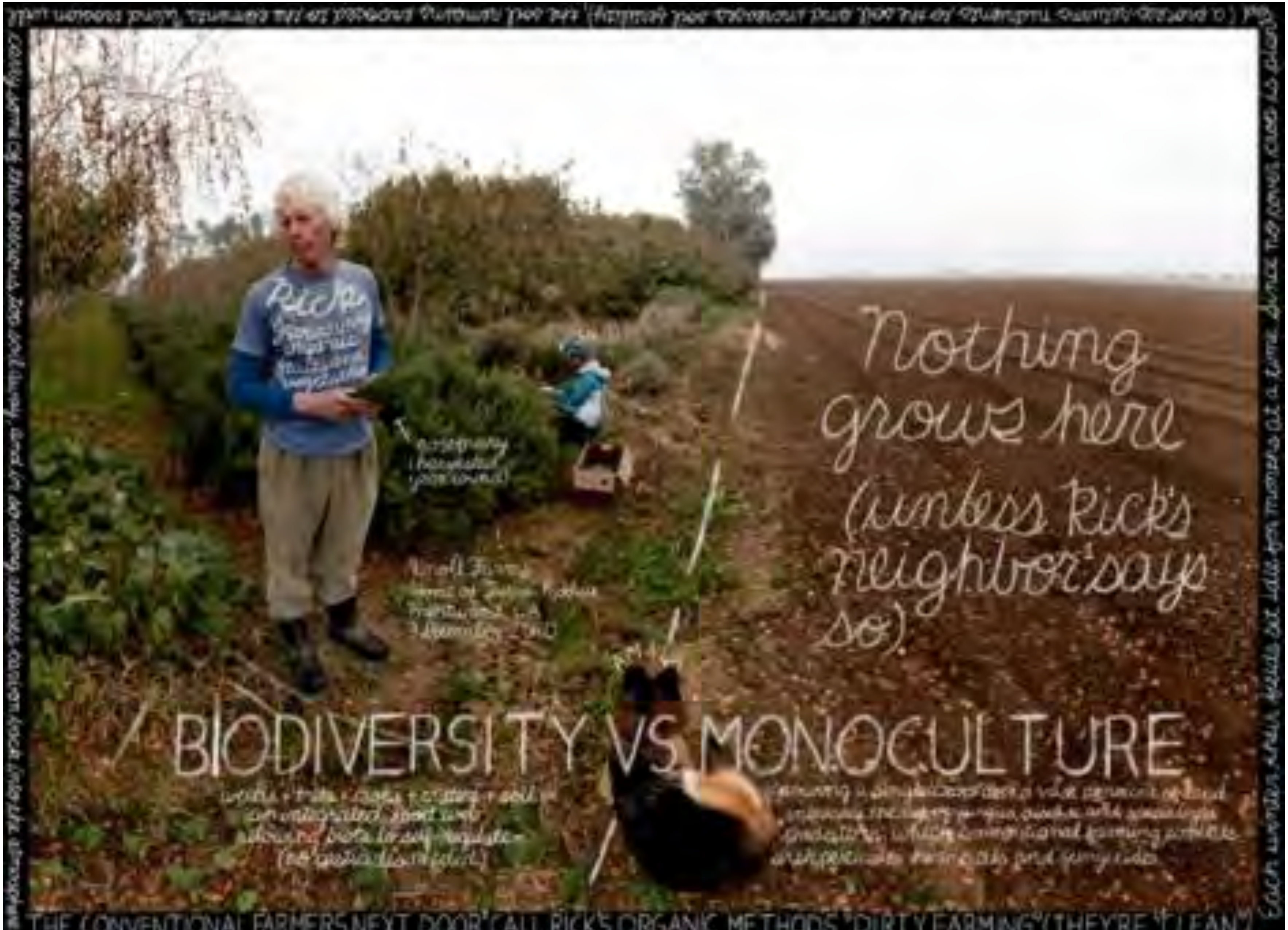
Basic Science:
Crop Rotation → Diversity → Health

Plants have different nutrient and mineral requirements and deplete the soil of certain elements while leaving behind other minerals, bacteria, and environments.

Crop rotation allows the plants' effects on the soil to benefit the next crop.

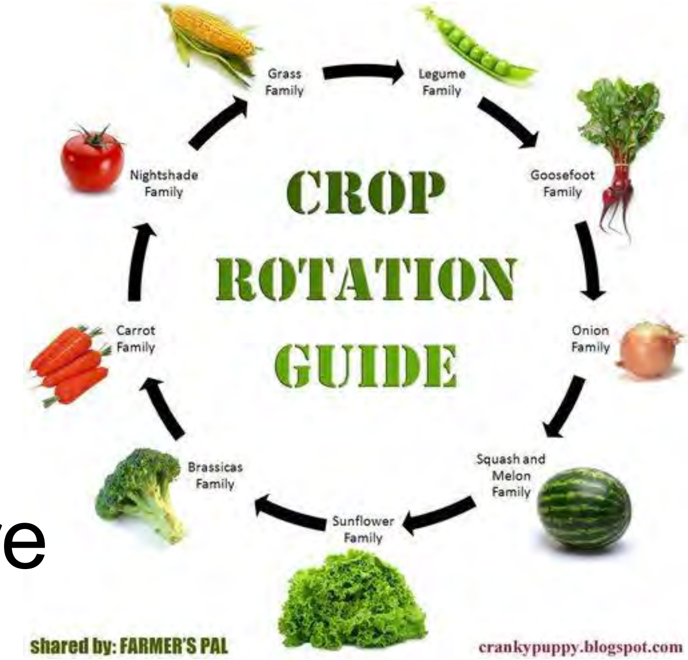
Basically, crop rotation capitalizes on what is already happening when plants grow, and prevents the negative consequences that can result from random plantings.

For a further breakdown of what crop rotation is see Agriculture 101



http://grist.org/sustainable-food/2012-01-13-lexicon-of-sustainability-biodiviersity-vs-monoculture/

Six Benefits:



1. Naturally fertilizes
2. Improves soil structure
3. Controls weeds, diseases, and harmful insects
4. Increases microbiology; bacteria and insects
5. Preserves the environment

Benefit 1: Naturally Fertilizes

- Balances minerals and nutrients by alternating heavy feeders and nitrogen fixers
- A well-managed legume rotation can add 150 pounds/acre of nitrogen --about half the inorganic nitrogen applied to corn in the Midwestern US http://people.oregonstate.edu/~muirp/sustfert.htm
- Soil organic carbon (SOC) is an important indicator of soil quality because it influences soil structure. Soil structure increases soil stability, as well as its capacity to hold water, and it is a driving force in nutrient cycling. SOC building is accomplished with crop rotation.
- Organic farmers can attempt to build higher SOC with sustainable farming practices. However, they should realize that following a change in land management, SOC changes slowly.

CEFS "Crop Rotations on Organic Farms" Keith Baldwin

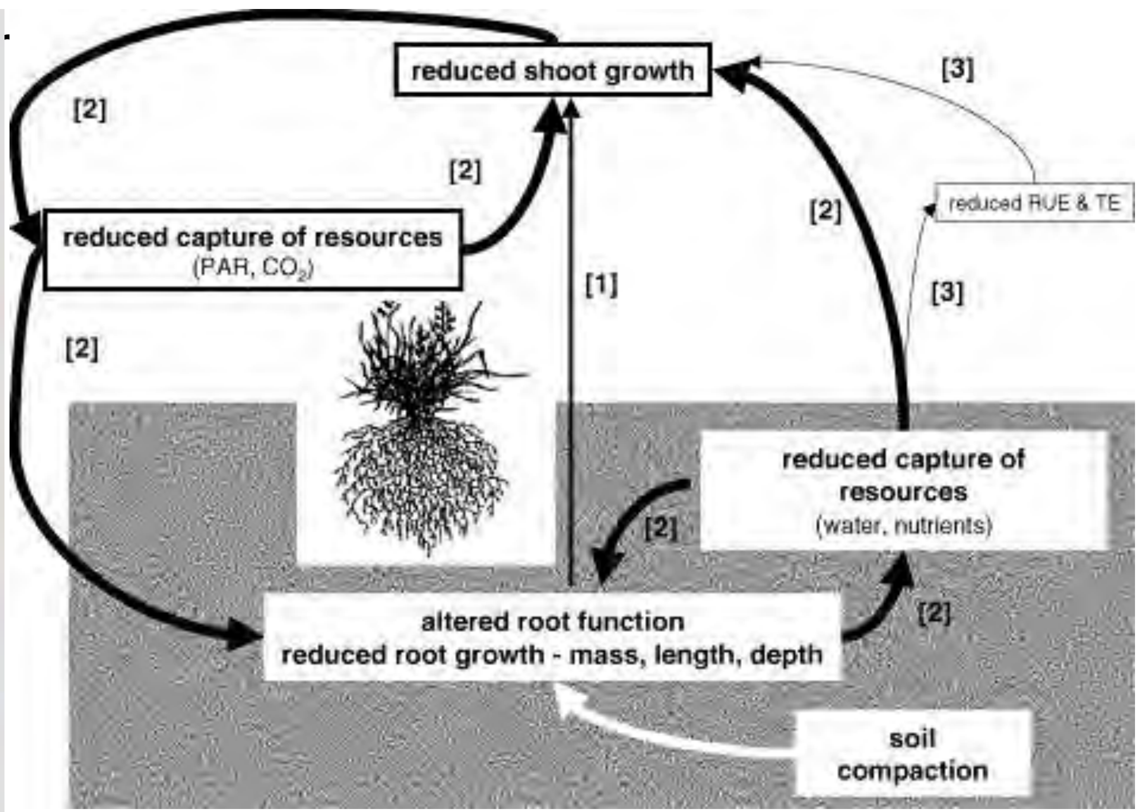
Benefit 2: Improves Soil Structure

- Increases the overall biomass of the soil
- Reduces need for tilling by alternating different root length plants to pull minerals up from subsoil
  http://soils.usda.gov/sqi/management/files/sq_atn_2.pdf
- Improves weed suppression by maintaining better soil health and providing living leguminous mulches which add nitrogen.
- Most problems are caused by, or made worse by continuous cropping. Inappropriate use of cultivation is largely responsible for soil structural decline. A pasture or crop phase that allows a build-up of organic matter in the soil (as through crop rotation) is a method of improving soil structure and soil structural stability.

  http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0010/127279/Improving-soil-structure-by-crop-

Benefit 2: Improves Soil Structure (cont)

- Crop Rotation should also alternate deep and shallow rooting plants to breaking up subsoil and reducing the effects of soil compaction as shown below right. These differing root systems also aerate the soil.
- C



Benefit 3: Controls weeds, diseases, and harmful insects

For example, Colorado potato beetles like to eat potato plants, but they also enjoy feasting on tomato leaves and eggplant foliage. Since these beetles overwinter in the soil, if you plant eggplant in a spot where you grew potatoes the year before, you could be inviting a beetle problem for your eggplants from the day they're planted. Likewise, several serious bacterial and fungal diseases overwinter in plant debris in the soil.

http://www.organicgardening.com/learn-and-grow/crop-rotation

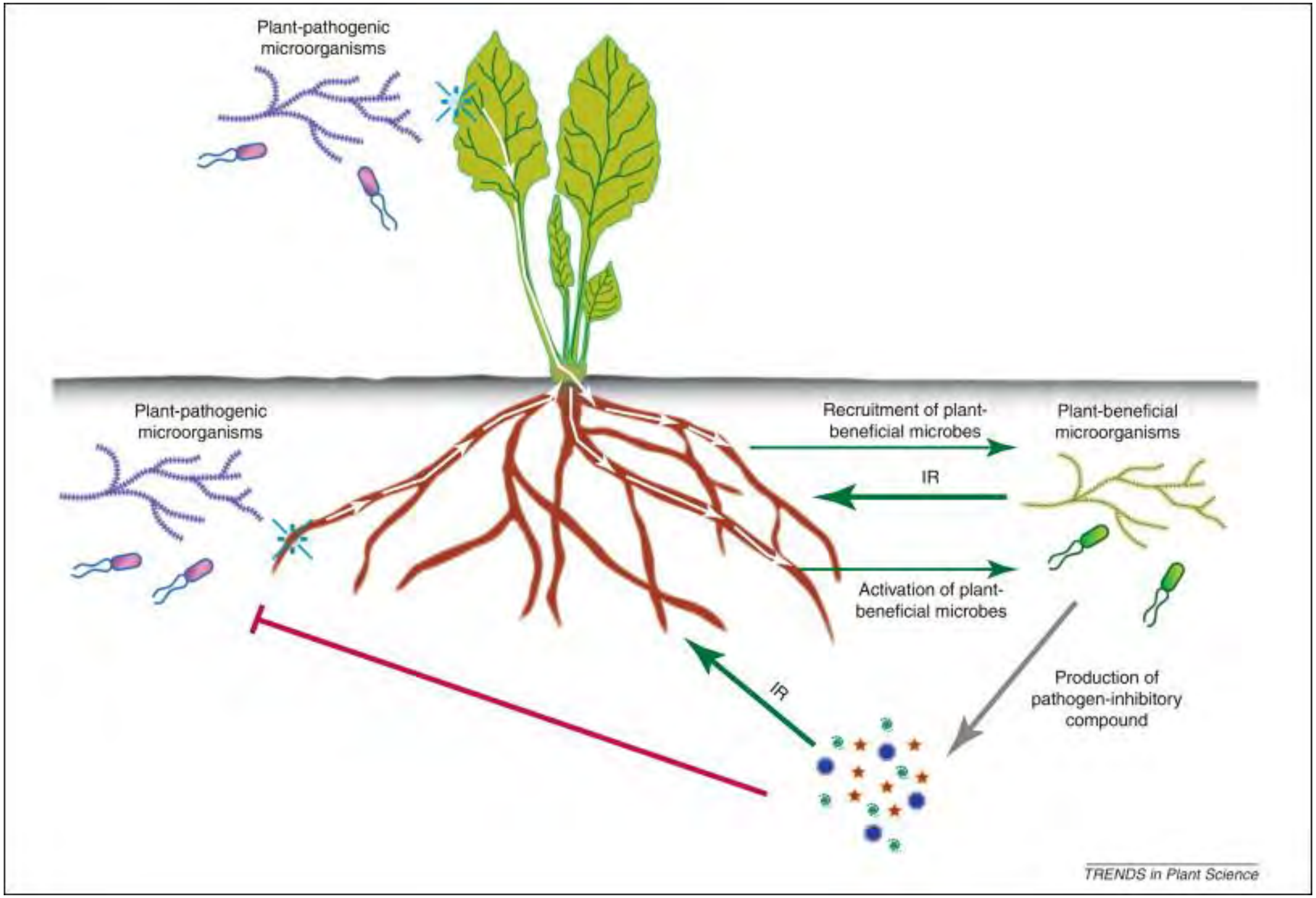
Benefit 3: Controls weeds, diseases, and harmful insects (continued)

- Disperses predator problems, big and small

- Lengthy rotations are sometimes necessary to control chronic soil-borne problems. Bean anthracnose fungus can persist in soil for up to three years, so a four-year rotation is needed to keep the disease at bay.

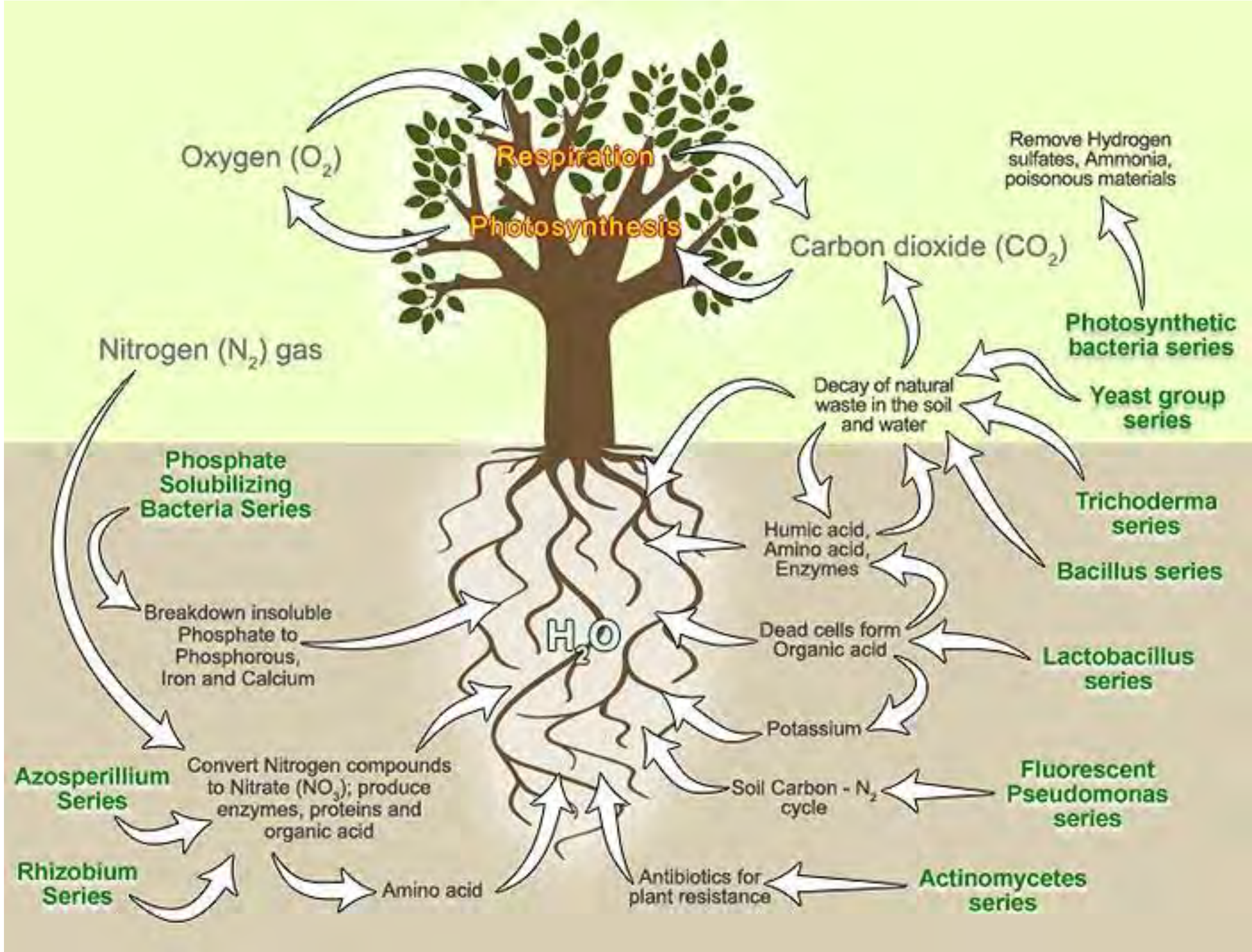
Benefit 4: Increases beneficial microbiology

- The key to great microbiology is diversity. Crop rotation aides in diversifying the soil food web.



Benefit 4 continued

Bacterial improvements for plants are enhanced by diversity of life through crop rotation



Benefit 5: Preserves the Environment

- Prevents erosion with deep roots and rich soil that holds on to water and nutrients
- Increases organic matter
- Improves physical properties of soil, allowing the earth to sustain life and healthy conditions
- Breaks cycles of disease, insect pests, and weeds
- Improve nutrient and water usage.

  http://soils.usda.gov/sqi/management/files/sq_atn_2.pdf

- A study conducted in 1988 found 6 inches more topsoil on an organic farm than on an adjacent conventional farm in the Palouse region of Washington state. *CEFS "Crop Rotations on Organic Farms" Keith Baldwin*

Benefit 6: Decreases Costs, Increases Revenue

- Crop rotation can increase yields when compared to continuous crops.
  http://aprodev.eu/files/Trade/crop%20rotation%20briefing_pan_ifoam_aprodev_foee_fina.pdf
- Provides valuable food and materials for livestock while enriching the soil.
- Less or no need for pesticides and artificial fertilizers
- Adds to crop and market diversity
- Crop Rotation allows for organic crops which are increasingly more important to consumers

  Cooking with Class

Cover Crops and Green Manures

A farmer decides to plant tomatoes, which are relatively *heavy* feeders, in late spring after all danger of frost has passed. In the early spring, in preparation for planting tomatoes, the farmer incorporates a hairy vetch cover crop into the soil to add organic matter and nitrogen to the soil. When the vetch is tilled in, it becomes a green manure.

The farmer chose hairy vetch as a cover crop because he/she knew that tomato plants need an early-season shot of nitrogen. Hairy vetch, with its low *carbon to nitrogen* (C:N) ratio and rapid decomposition rate, can fulfill that need.

peas

Detailed Science: Importance of Legumes

vetch

- Legumes are described as “nitrogen fixing" plants. Legumes collect nitrogen from the air and fix it on the root systems in the form of nodules.
- Legumes are a great crop to alternate with heavier feeding plants such as corn. The legumes add nitrogen to the soil after the plant is harvested or dies back.
- Legumes fix nitrogen through a symbiotic relationship with bacteria known as rhizobia that is naturally occurring in soil but often introduced in the form of inoculants by the farmer planting the legume.
- **Two types of legumes that are farmed are forages and grain. Common forages are: alfalfa, vetch, and clovers. Common grains are: Beans, lentils and peas.**

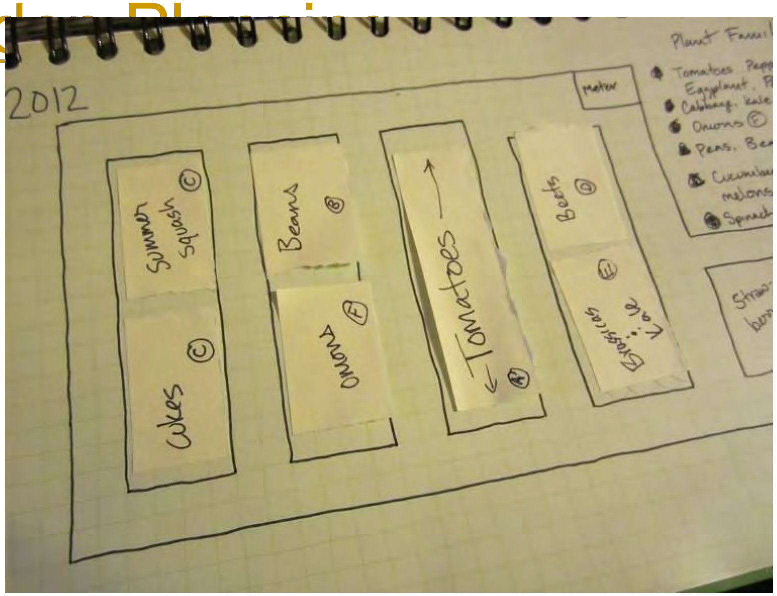
How to rotate crops?

Identify Plant Families

- By type (more reliable) [How to Rotate Vegetable Crops]
- By feeding categorization [Gard]

Design your Garden

- [Designing a garden]



Then, rotate subsequent years' crops

by following a rotation plan.

Sample plans include…

The Corn Belt system on large farms:

- Apply manure, grow corn, follow with soybeans, apply manure, grow corn, and follow with several plantings of alfalfa. In this rotation, legumes fix nitrogen in the soil before the heavy feeder crop (corn, in this example.) Specific plant pest cycles are interrupted. Specific plant disease is similarly suppressed. In this crop rotation, alfalfa cultivation also serves to smother weeds. Manure is applied before the heaviest feeder. Livestock feed is grown for use on farm or for sale.

Intensive vegetable rotational system- 8 years/steps:

This eight year rotational cycle can be adapted to many growing regions. Sweet corn followed by tubers followed by squash, followed by root crops then beans followed by tomatoes, followed by peas then brassicas. This style has been most recently made popular by Eliot Coleman and is benefited by the following relationships.

But why? Read on.

Rotational considerations: Plant by plant

- **Potatoes** follow sweet corn…because research has shown corn to be one of the preceding crops that most benefit the yield of potatoes.
- **Sweet Corn** follows the cabbage family because, in contrast to many other crops, corn shows no yield decline when following a crop of brassicas. Secondly, the cabbage family can be undersown to a leguminous green manure which, when turned under the following spring, provides the most ideal growing conditions for sweet corn.
- **The Cabbage Family** follows peas because the pea crop is finished and the ground is cleared [early] allowing a vigorous green manure crop to be established.

Coleman, Eliot *New Organic Grower*

Rotational considerations: Plant by plant

- **Peas** follow tomatoes because they need an early seedbed, and tomatoes can be under-sown to a non-winter-hardy green manure crop that provides soil protection over winter with no decomposition and re-growth problems in the spring.
- **Tomatoes** follow beans in the rotation because this places them 4 years away from their close cousin, the potato.
- **Beans** follow root crops because they are not known to be subject to the detrimental effect that certain root crops such as carrots and beets may exert in the following year.

Coleman, Eliot *New Organic Grower*

Rotational considerations: Plant by plant

- **Root Crops** follow squash (and potatoes) because those two are good cleaning" crops (they can be kept weed-free relatively easily), thus there are fewer weeds to contend with in the root crops, which are among the most difficult to keep cleanly cultivated. Second, squash has been shown to be a beneficial preceding crop for roots.
- **Squash** is grown after potatoes in order to have the two cleaning" crops back to back prior to the root crops, thus reducing weed problems in the root crops

Coleman, Eliot *New Organic Grower*

Rotation Plans in 4 steps

A Vegetable-Growing Guide for Beginners

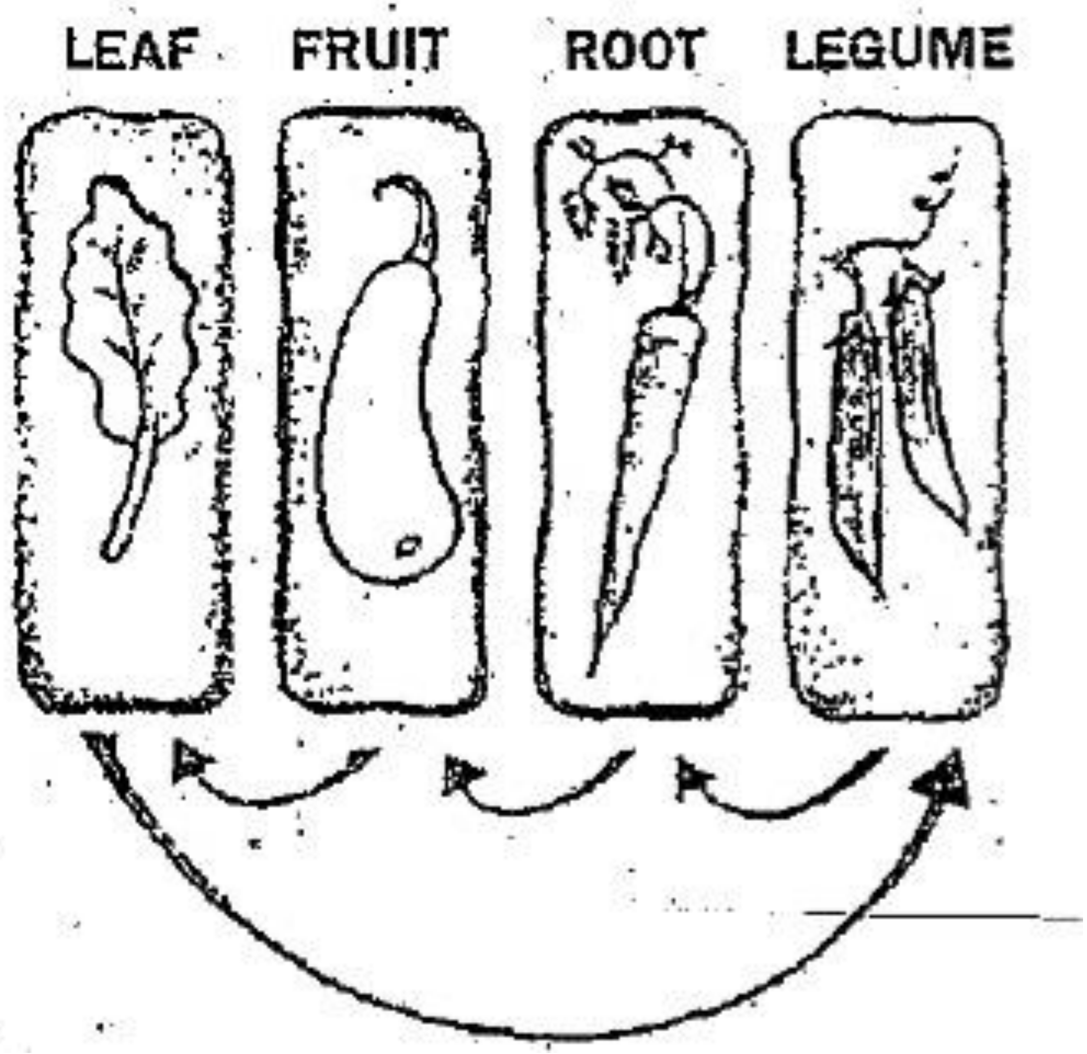
CROP ROTATION

Plot	Season	Year 1	Year 2	Year 3	Year 4
1	Summer	Potatoes, Tomatoes	Peas and Beans	Cabbages	Carrots, Parsnips, Celery, Beetroot, Spinach and Swiss Chard and Lettuces
	Winter	Onions, Garlic, Leeks	Green Manure	Cabbages with Lettuces	Green manure
2	Summer	Carrots, Parsnips, Celery, Beetroot, Spinach and Swiss Chard and Lettuces in between	Potatoes, Tomatoes	Peas and Beans	Cabbages
	Winter	Green manure	Onions, Garlic, Leeks	Green Manure	Cabbages with Lettuces
3	Summer	Cabbages	Carrots, Parsnips, Celery, Beetroot, Spinach and Swiss Chard and Lettuces	Potatoes, Tomatoes	Peas and Beans
	Winter	Cabbages with Lettuces	Green manure	Onions, Garlic, Leeks	Green Manure
4	Summer	Peas and Beans	Cabbages	Carrots, Parsnips, Celery, Beetroot, Spinach and Swiss Chard and Lettuces	Potatoes, Tomatoes
	Winter	Green Manure	Cabbages with Lettuces	Green manure	Onions, Garlic, Leeks

Another way to consider the 4 year rotation

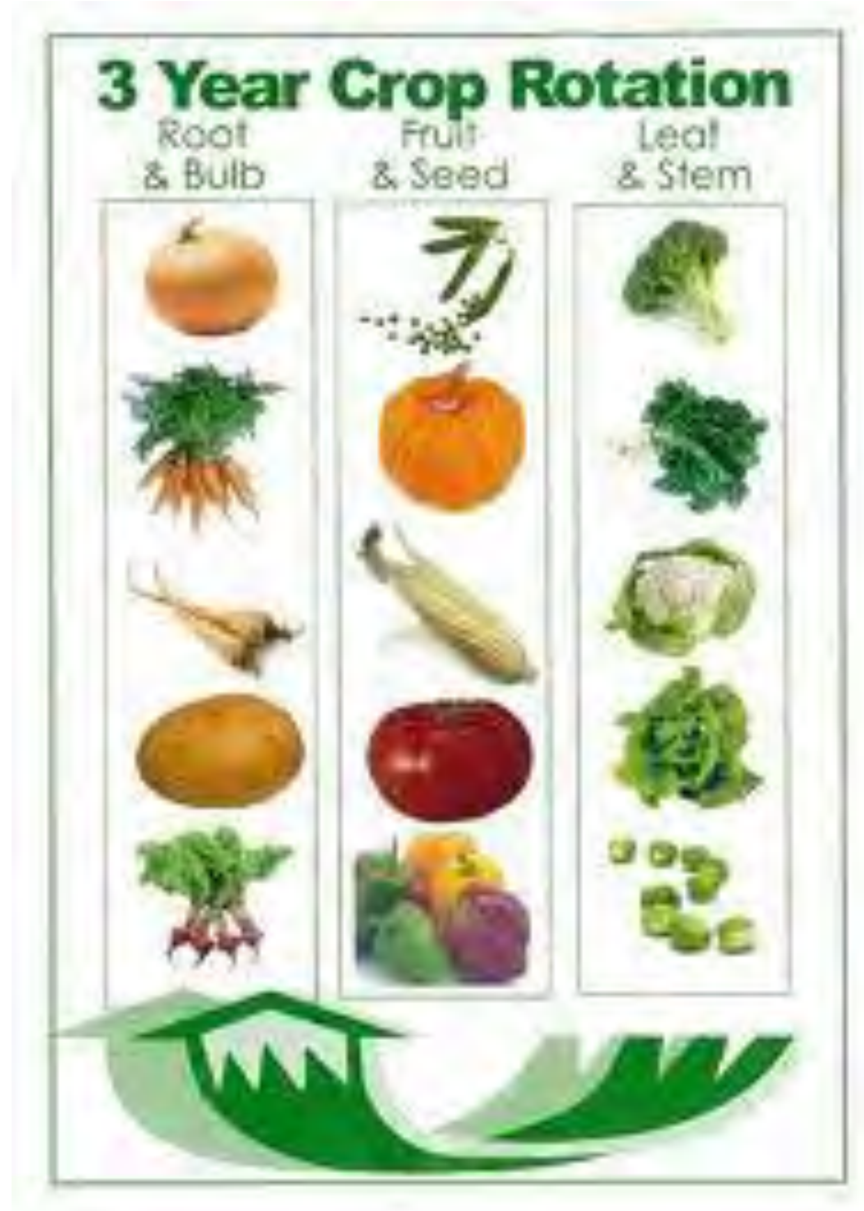
	Year 1	Year 2	Year 3	Year 4
Bed 1	Potatoes family & compatible plants followed by lime	Legumes (Peas/ Beans) followed by additional lime	Brassicas family & compatible plants	Onion family & compatible plants followed by manure
Bed 2	Legumes (Peas/ Beans) followed by additional lime	Brassicas family & compatible plants	Onion family & compatible plants followed by manure	Potatoes family & compatible plants followed by lime
Bed 3	Brassicas family & compatible plants	Onion family & compatible plants followed by manure	Potatoes family & compatible plants followed by lime	Legumes (Peas & Beans) followed by additional lime
Bed 4	Onion family & compatible plants followed by manure	Potatoes family & compatible plants followed by lime	Legumes (Peas & Beans) followed by additional lime	Brassicas family & compatible plants

Even simpler look at 4 year plans



Crop Rotation in 3 Steps… not quite

Though commonly used, this plan is missing a few important elements. How many can you spot?
(*nitrogen fixers are not separate from heavy feeders, need minimum of four years for common soil born problems*)



Assessment/Review

- Why is it important to have a solid understanding of characteristics of specific crops and the relationships between specific crops in order to design an effective crop rotation system?
- What is the importance of legumes in a rotational cycle of planting?
- What are some specific benefits to rotating crops?
- How does rotating crops keep the soil structure healthy?

Resources

- Coleman, Eliot *New Organic Grower*
- *USDA*
- *SARE*

Primary Tillage

Objectives

This presentation will outline

- Tillage solutions for **permaculture and organic farms**
- Definitions of tillage and cultivation
- Positive and negative effects of tillage on physical and biological properties of the soil
- Conditions for tillage depending on soil types
- Seasonal consideration
- Types of tillage equipment
- Common soil preparation sequence used in primary tillage

Terms and Definitions

- **Cultivation**: The total assemblage of tools and techniques used to develop and maintain soil fertility and crop production in garden and farm systems
- **Tillage**: Mechanical manipulation of the soil to prepare seedbeds

Tillage in permaculture

Permaculture farms attempt to maintain natural soil structures as much as possible. Considerations for permaculture:

- How does nature regenerate healthy soil? (Leaves and other organic matter decay on the soil surface.)
- Is tillage necessary in all cases? (See slides No Till Methods for Permaculture)
- Are there ways to lay out your farm that minimize tillage? (Perennials help minimize a farm's tillage requirements.)

Terms and Definitions

Primary Tillage:

Course and deep tillage that cuts, fractures, and mixes the soil. It creates a soil condition from which a seed bed can be prepared.

Secondary Tillage:

Tilling which reduces the surface soil particle size; helpful for seed bed preparation

Land shaping:

Forming vegetable beds, concerns land height of 6 to 8 inches, and may apply plasticulture .

Cultivation:

The mechanical management of weeds and residues

Purposes for Tillage

- **Maintain good soil structure**

  Opens up compacted soil, allows for vertical transfer of organic matter, creates soil aggregates, and decreases soil particles in order to create a good seedbed

- **Aerate the Soil**

  Increases soil/air exchange and increases water infiltration

- **Increase the temperature of cold soils**
- **Incorporate organic matter, cover crops, or crop residues**
- **Break up soil pans**
- **Control weeds**
- **Dry the soil before seeding**

Negative Effects of Tillage

Compaction of soil below the depth of tillage (hard pan)

Soil loses nutrients and organic matter

Reduced biological activity and loss of earthworm activity

Destruction of soil aggregates

Soil loses ability to store water and soil loses ability to drain well

Loss of soil pore space

Erosion of the soil

Cost of tillage equipment and energy costs of tillage operation

Types of Soil

Clay soil -

Avoid tilling soil that is too wet . Clay soil that is too dry will be too hard to till. Optimal time to till is early spring, after rainfall but not when soil has dried out

Sandy soil-

Till when moisture content is high. This allows soil particles to stick together so the wind will not blow soil away. Higher moisture content will help to avoid powdering of the soil.

Seasonal Considerations

(Temperate Climate – Outdoors)

Spring Till

Incorporate cover crops, warm cold soils, aerate, incorporate organic matter, create planting beds

Summer Till

Surface tillage for successive planting

Fall Till

Prepare soil for fall and overwinter crops, incorporate minerals and organic matter, shape raised beds and compost the tops of raised beds

Winter Till

No cultivation except in greenhouses. When warm enough, till top of raised beds

Tillage and Soil Health

Video: Effects of Tillage on Soil Health

http://youtu.be/pCj58isK1xE

Primary Tillage Equipment

- Flail Mower
- Moldboard Plow
- Chisel Plow
- Disk Plow
- Subsoiler

Reference: ftp://ftp-fc.sc.egov.usda.gov/IA/intranet/Tillage.pdf

Secondary Tillage Equipment

- Spader and Harrow
- Bedshaper

Reference: ftp://ftp-fc.sc.egov.usda.gov/IA/intranet/Tillage.pdf

Flail Mower

Video: Flail Mower

- To prepare beds for plowing
- Mow cover crop

http://youtu.be/HJOYZQiP4Wg

Moldboard Plow

- Inverts soil in a plow layer
- Breaks up turf
- Incorporates cover crops
- Buries crop residues
- Can cause a tillage pan

Moldboard Plow

- Moldboard Plow
- In clay soil, till above the clay line (depth of around 4 inches)

Video: Moldboard Plow

http://youtu.be/cNCqkmlk5FI

Moldboard Plow

Field after plowing

Chisel Plow

- Fractures the soil
- Does not invert soil
- Mixes soil and surface residue
- Not effective for weed control

Photo from www.bucktraco.com

Video: Chisel Plow and Field Cultivator to Prepare Fields

http://youtu.be/eOrzuu5I_gc

Disk Plow

- Inverts the soil
- Breaks up large clumps
- Levels the surface

Disk Plow Videos

http://youtu.be/6a398x22I9s

http://youtu.be/FgnLyfpqvdA

Subsoiler

- Used to break up hard pans
- Fractures the soil but does not invert soil
- Can reach depths of 12 to 24 inches

Spader and Harrow

Video: Soil Spader to Incorporate Cover Crops and Compost

- Used for seedbed preparation
- Does not invert soil
- Levels the surface

http://youtu.be/ycadZjZ1Vnw

Rotary Tiller

- Used for seedbed preparation
- Breaks up large clumps
- Levels the surface

Bedshaper

Video: Bedshaper

- Used for seedbed preparation
- Creates a raised bed for seeds and transplants

http://youtu.be/5EJ0YfVxsLU

Tillage Sequence

- Mowing Plow
- Moldboard plow
- Disk
- Rotary Tiller
- Bedshaper

No Till Methods (for permaculture)

I am always impressed when I remove a straw mulch that has been down for a few months. The improved soil structure from the extra earthworm activity emphasizes how effective nature can be when I don't interfere.

-Eliot Coleman

No Till Methods

- Use disk or chisel plow to prepare for seeding.
- Does not turn over the soil.
- Creates narrow furrow for planting.
- Use cover crops during non–growing seasons.
- Flail mowers cut and chop cover crops and leave residue on the field.
- Planting is done through the residue that is left on the field.

http://www.extension.org/pages/18634/use-of-tillage-in-organic-farming-systems:-the-basics

No Till Methods

- Used for seedbed preparation
- Does not invert soil
- Levels the surface

Video: Small Scale No Till Using Compost as Mulch

http://youtu.be/XSvLkh5oOsY

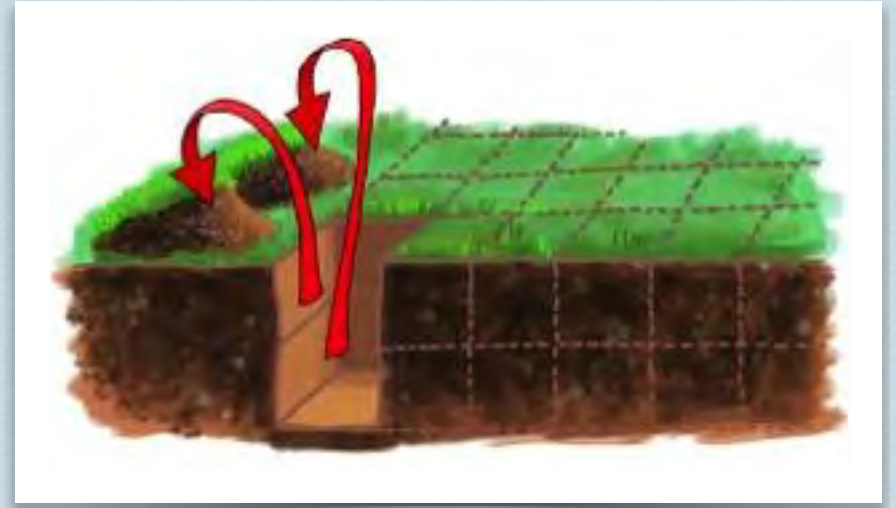
Small Scale

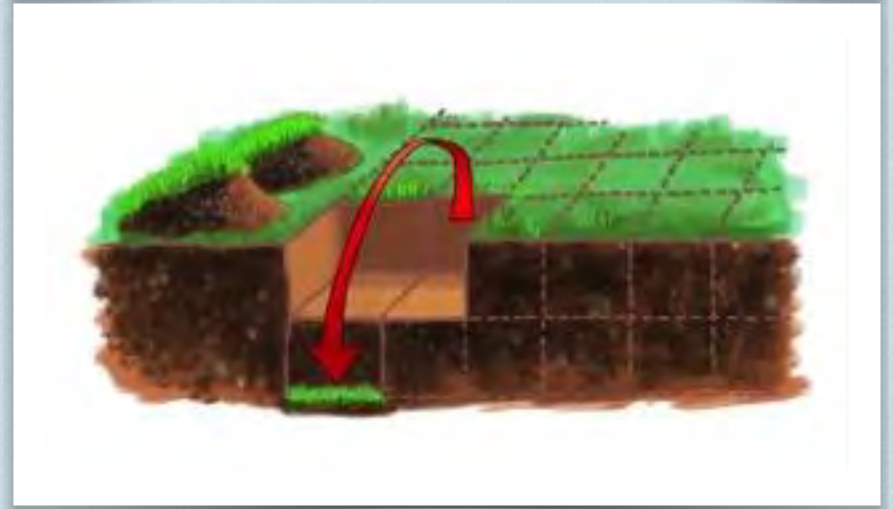
- Push Plows
- Rotary Plow
- Broadfork

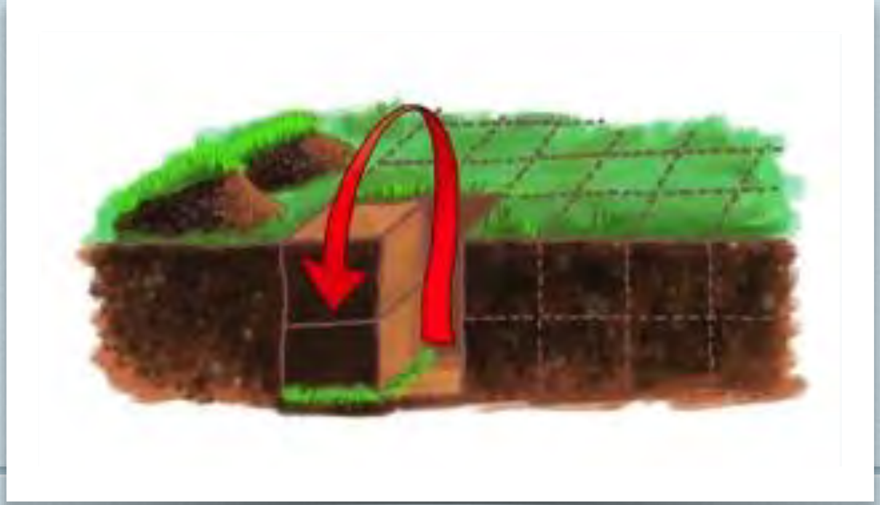
http://broadforkfarm.files.wordpress.com/2011/01/dsc_0056.jpg

Double Digging

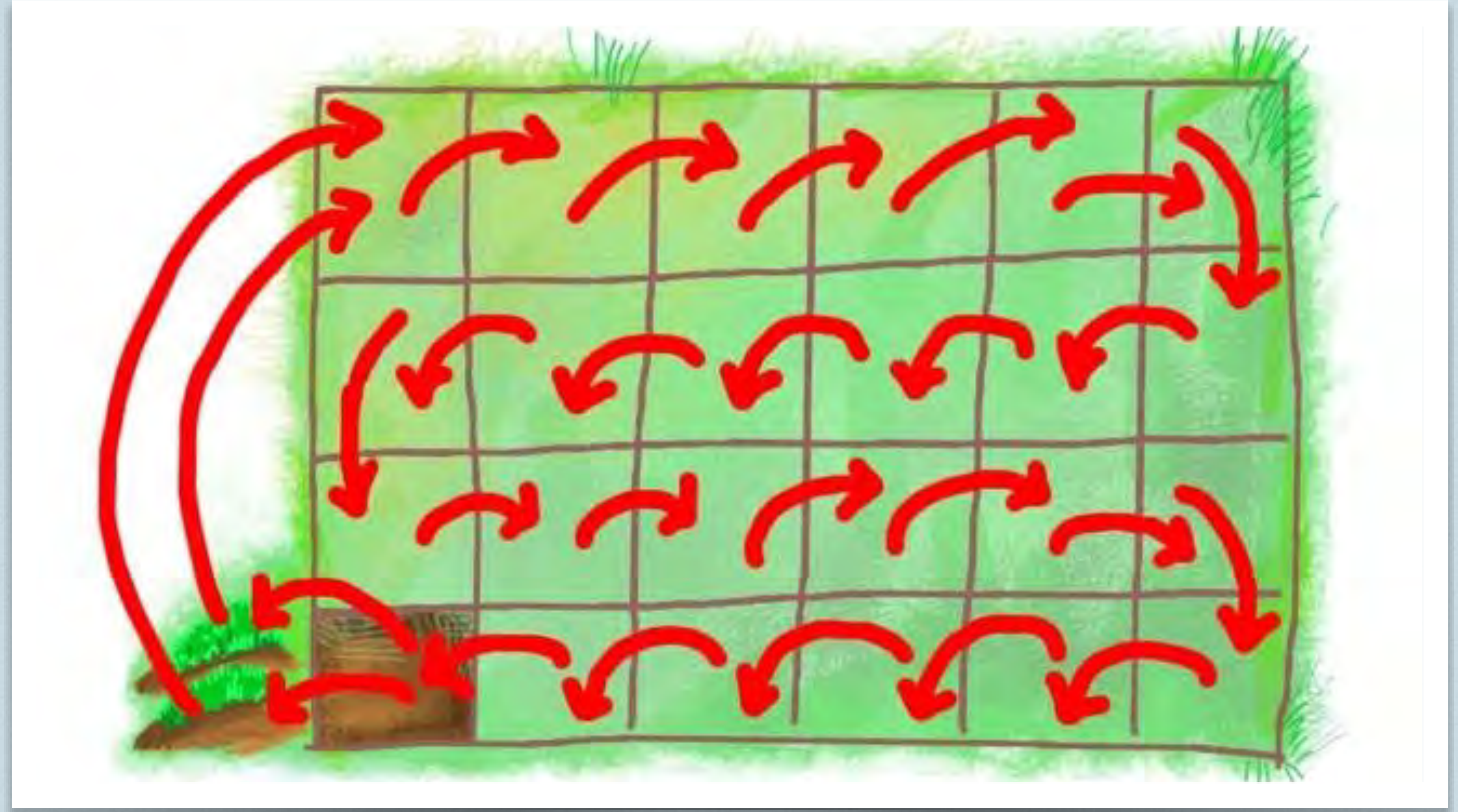
- Dig one cubic foot of soil – set aside
- In the same hole - dig the next cubic foot of soil – set aside
- Dig a second neighboring cubic foot of soil – put turf down into the first hole.
- Dig another cubic foot of soil from neighboring hole – overturn and put into the first hole.
- Continue







Double Digging



Self Review Questions

- What is the purpose of tilling?
- What are the drawbacks to tilling?
- How do seasons, weather ,and water conditions affect tilling?

Summary

- Ask yourself: Is tillage necessary?
- Avoid tillage when soil is too wet or too dry.
- Vary depth and type of tillage to minimize hardpan formation.
- Cultivate shallowly, no deeper than needed to control weeds.

From http://www.extension.org/pages/18634/use-of-tillage-in-organic-farming-systems:-the-basics

References

The New Organic Grower, Eliot Coleman

http://campus.extension.org/course/category.php?id=31

http://casfs.ucsc.edu/education/instructional-resources/downloadable-pdf-files

http://old.huhs.org/departments/agriculture/hennes/documents/conservationtillagepractices.pdf

http://www.windcrestorganics.com/curriculum.html

http://www.bvsd.org/curriculum/CTEC/Curriculum%20Essentials%20Documents/Urban%20Agriculture.pdf

http://ofrf.org/education/database

http://www.sare.org/Learning-Center/Courses-and-Curricula

http://georgiaorganics.org/for-farmers/fundamentals-of-organic-farming-and-gardening-an-instructors-guide-revised-for-2009/table-of-contents/

http://www.extension.org/pages/18634/use-of-tillage-in-organic-farming-systems:-the-basics

http://extension.psu.edu/agronomy-guide/cm/sec1/sec11g

Seeds

Family → Genus → Species → Variety

Ex. Carrots:

Apiacea → Daucus → Carrota → "Scarlet Nantes"

Understand the Basics of Seed Propagation

- The learner will understand the basics of plant:
  - Botany
  - Pollination
  - Breeding
  - Saving

First: Basic Botany

- The kingdom *Plantae* features multicellular organisms that are most often characterized by their ability to *photosynthesize*, or convert solar energy into chemical energy.
  - The most important plants to farmers are the *angiosperms*, or flowering plants. These plants use flowers as their method of reproduction.
    - The flower produces the seed, which contains the genetic material for producing a new separate plant.

Seed Basics: http://www.youtube.com/watch?v=iv5JjH4kD1k

Plant Taxonomy

- Plants are divided into species, which are further divided into *varieties*.
  - Varieties of a single species will differ from each other in some regard, but can still reproduce and create viable offspring.

- For instance, there are well over 100 varieties of green beans.

What Are Seeds?

- Seeds are the mature, fertilized ovules of plants and the means by which plants reproduce. In essence, a seed is the embryo of a new plant that will grow upon certain conditions.

Life Cycle Length

- Plants produce seeds at different rates; we categorize plants based on the length of their life cycle, and thus seed production.

TITLE	LIFE CYCLE LENGTH
Annual	One year
Biennial	Two years
Perennial	More than two years

Biennials include:

Annual vs. Biennial seed producers

carrots

beets

parsley

Swiss chard

kale

leeks

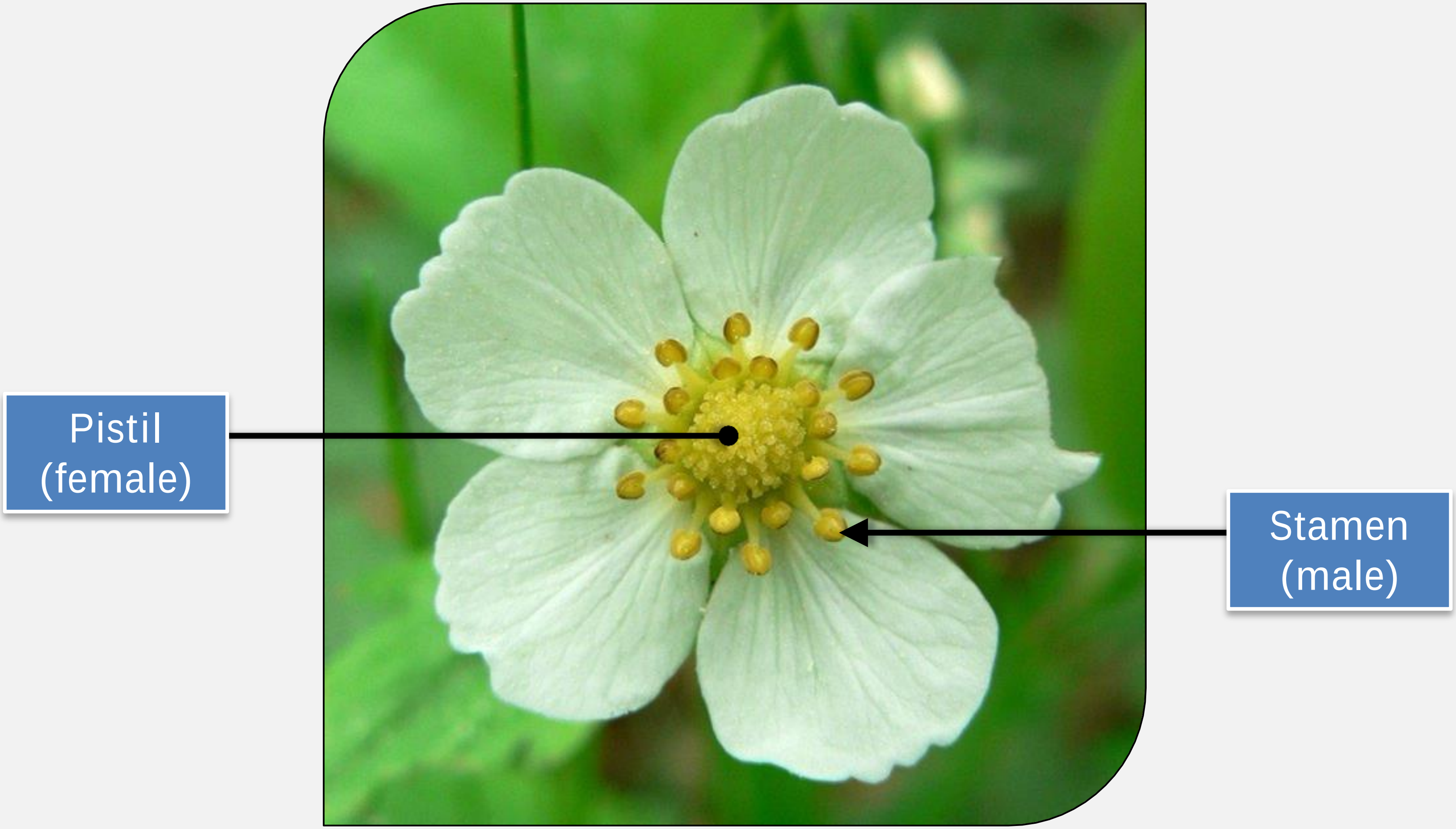
AND..

Cabbage family & onions

Plant Reproductive Anatomy

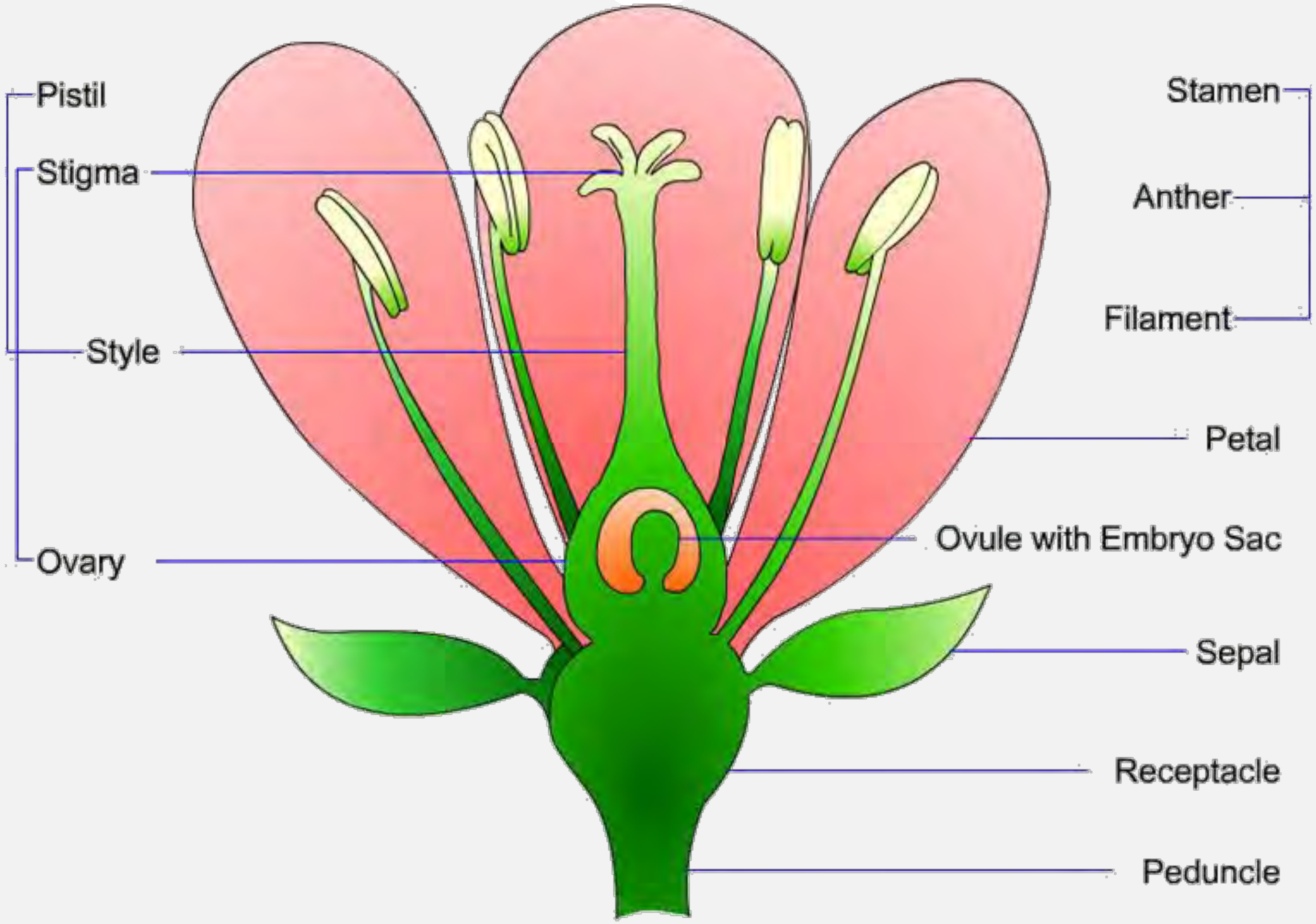
- Plants have sexual organs: the stamen (male) and pistil (female).
  - The stamen has a specific part, the *anther*, that produces *pollen grains* that contain the male germ cells.
  - The ovules of the pistil produce female germ cells.
    - When the pollen grains unite with the ovules, fertilization occurs and the flower produces seeds.

Stamen and Pistil



Strawberry flower (*Fragaria x ananassa*)

Flower Parts



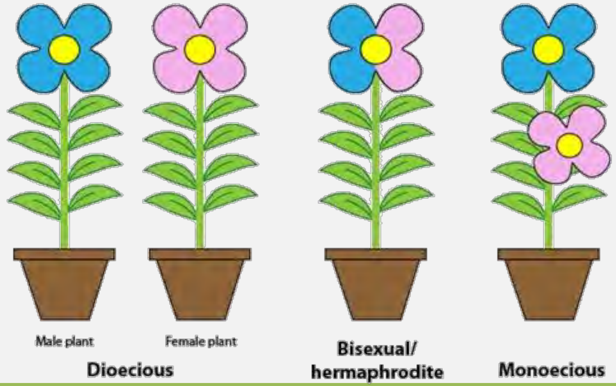
Types of Flowers

- Some plants have *perfect flowers*, which contain both sexual organs, whereas other plants have *imperfect flowers*, which have only one sexual organ.

Thus, you know that this is a *perfect flower*

Monoecy vs. Dioecy

- Plants with imperfect flowers are divided into categories of *monoecious* and *dioecious*.
  - Monoecious plants have both male and female flowers on each plant.
    - Most flowering plants are monoecious.
  - Dioecious plants instead have one type of imperfect flower (male or female) on each plant and rely on another plant to complement the sexuality.
    - These include asparagus and spinach.



Pollination

- Plants either self-pollinate or cross-pollinate.
  - Self-pollination is a form of asexual reproduction; the plant simply pollinates itself, thus creating genetically identical offspring.
  - Cross pollination, in turn, requires two different plants that will create genetically different offspring.

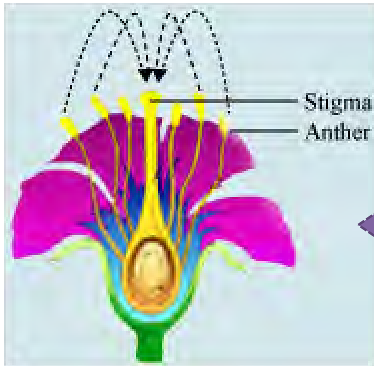
Louie Schwartzberg – The Hidden Beauty of Pollination- http://www.youtube.com/watch?v=eqsXc_aefKI

Pollination

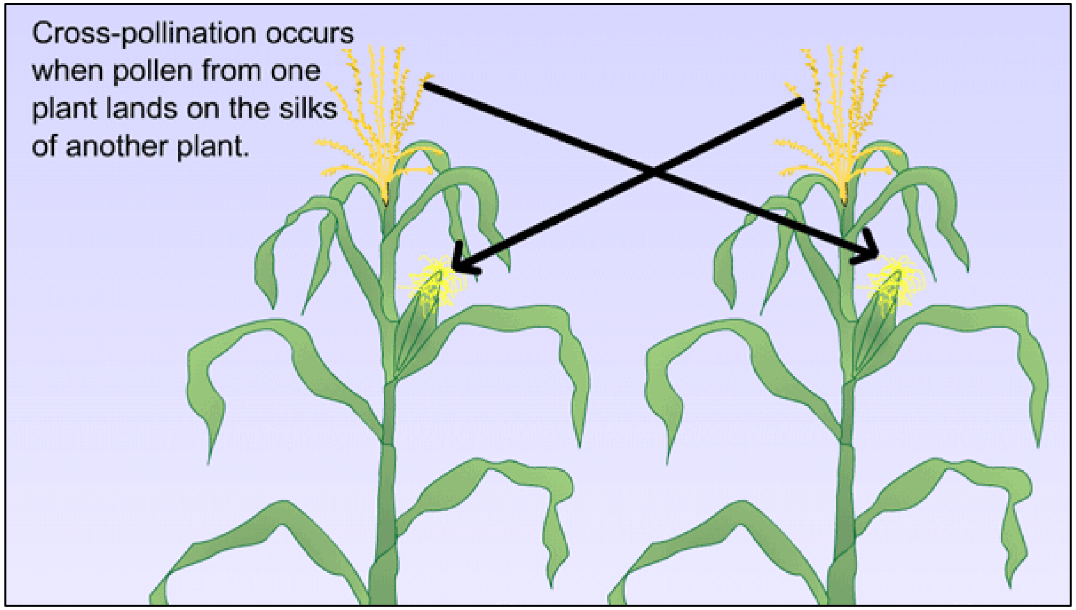
- Plants that *only* self-pollinate include:
  - Bush and pole beans
  - Peas
  - Tomatoes, Peppers, Eggplant
  - Lettuces
- Plants that *only* cross-pollinate include:
  - Cabbages
  - Radishes

- Most other plants can both self- and cross-pollinate.

Self-Pollinated:

(a) Type I	(b) Type II
	
It occurs within the same flower. Pollen from the anther is transferred to stigma of the same flower.	It occurs between two flowers of the same plant. Pollen from the anther of one flower is transferred to stigma of another flower in the same plant.

Cross Pollination:



Cross pollinated plants need isolation from one another (usually a minimum of ½ mile) when planting more than one variety of the same species in order to keep the breed clean . This can be accomplished by time isolation as well. Planting times are staggered to avoid overlapping flowering and unwanted crossing of pollen(works well with corn).

All Vegetables Require Pollination: http://newstimes.augusta.com/stories/2011/02/20/new_606469.shtml

Pollination Mechanisms

- Plants pollinate by either *biotic* or *abiotic* mechanisms.

Biotic mechanisms rely upon animals and can be conducted by bees, moths, bats, birds, and many other organisms.

Abiotic mechanisms are wind and water, which can carry the pollen grains to other flowers.

Britannica – Methods of Pollination

– Seed Dispersal

Genetics: Inbreeding Depression

- Plants require genetic variability in reproduction on the population level, or the population will undergo *inbreeding depression*, where many individuals will develop undesirable and potentially self-threatening traits.

- Thus, while self-fertilization has obvious benefits to the reproduction of an individual plant, it cannot sustain a whole population.

Avoiding Inbreeding Depression: http://www.flexiguru.com/expert/how-do-plants-overcome-inbreedingdepression-8477

Hybrid Offspring

- Remember the slide about plant taxonomy? Each species can have multiple *varieties* of plants.
  - Breeding between different varieties results in *hybrid* offspring.

Seedless watermelon is simply an infertile hybrid; it is a triploid offspring produced by crossing one diploid and one tetraploid watermelon.

Genetics: Heterosis

- Opposite of inbreeding depression, a population can experience *heterosis,* or *hybrid vigor*, which is the production of positive traits in offspring due to hybrid crosses.
  - For this reason, over 95% of the corn grown in the U.S. is from hybrid seeds. Corn farmers purchase these seeds each year, rather than growing their own.

Genetic Modification GMO

- Geneticly Modified seed is the result of scientifically altering DNA of that seed; usually using genes of a different plant life to alter the characteristics of the plant or fruit of that seed (to make it more profitable).

ie-GMO corn and soybeans have altered DNA to with stand applications of Round Up(herbicide) with out dying like all other surrounding plant life(and microbiology).

GMO seed is not allowed in organic production and it threatens the sustainability of seed variety and species.

http://gmoanswers.com/explore?gclid=CI7ApMbsxL0CFc9AMgodi2gAMw

Seed Saving

- Selecting plants from which to save seed should be an extended process of observation.
- Plants should be evaluated for their positive characteristics and marked appropriately.
- When that crop goes to seed, the marked plants can serve as parents for future plantings.

How to Save Seeds: http://www.youtube.com/watch?feature=player_embedded&v=L_Yncr8rTfc

Seed Saving: Wet vs. Dry Processing

- Seed saving can be done by either dry or wet processing.
  - Many plants permit their seeds to dry out naturally before a farmer harvests them, such as beans or corn.
  - However, certain plants require *wet processing*, in which the harvester dries the seeds if he or she wishes to store them. These plants include tomatoes, melons, eggplant, squash, cucumbers, and peppers.

Benefits of Saving Seed

- Saving seed has many benefits.
  - Small farms saving seed supports biodiversity among the plants and thus the populations are better adapted for pest and disease resistance.
  - Through natural selection the plants adjust to the soil and microclimates of the individual farm.
  - The practice costs less financially and reduces farmer dependence upon regional and/or national seed companies.

Self Review

1. Name the parts of a flower. How do self pollinating differ from cross pollinating?
2. Talk about the positive and negative effects of hybridization.
3. What is the general life cycle of a self pollinating flower.
4. How are wet seeds saved? Why is seed saving important?
5. Give examples of fruits/vegetables that are self pollinating and cross pollinating?

Books for More Information

- Suzanne Ashworth and Kent Whealy – Seed to Seed
- Brian Capon – Botany for Gardeners
- Eliot Coleman – The New Organic Grower
- Carol Deppe – Breed Your Own Vegetable Varieties

Photograph Sources

- Slide 3 - beautifulcataya. “Fresh Green Beans.” Photograph. Fotopedia. Web. 12 Aug. 2012.
- Slide 4 - Kratochvil, Petr. “Grain Plant Seed.” Photograph. Public Domain Images. Web. 12 Aug. 2012.
- Slides 7 & 8 - Rosendahl. “Wild Strawberry Flower.” Photograph. Public Domain Images. Web. 12 Aug. 2012.
- Slide 12 - Sullivan, John. “Bee pollinating the basil on my balcony.” Photograph. Public Domain Images. Web. 12 Aug. 2012.
- Slide 13 - Brooks, Leon. “Sunlight over picket fence.” Photograph. Public Domain Images. Web. 12 Aug. 2012.
- Slide 15 - Depolo, Steven. Photograph. Nopsa. Web. 12 Aug. 2012.
- Slide 16 – Culturally Authentic Pictorial Lexicon. Photograph. Web. 12 Aug. 2012.
- Slide 18 - Sullivan, John. “Chillies chillies peppers seeds pods.” Photograph. Public Domain Images. Web. 12 Aug. 2012.

Greenhouses

Objectives

Students will learn...

Differences between different types of greenhouse structures

How to design a greenhouse that fits their production needs and fits into a particular farming plan.

Basic techniques for managing and growing in greenhouses (organic and permaculture approaches)

Definitions

greenhouse: a glass or plastic-covered building which protects plants from cold weather

hoop house: an unheated greenhouse

cold frame: a small version of a hoop house; plants are often accessed from outside the structure

hot bed: a cold frame with supplemental heat

Different options

1. Hoop House

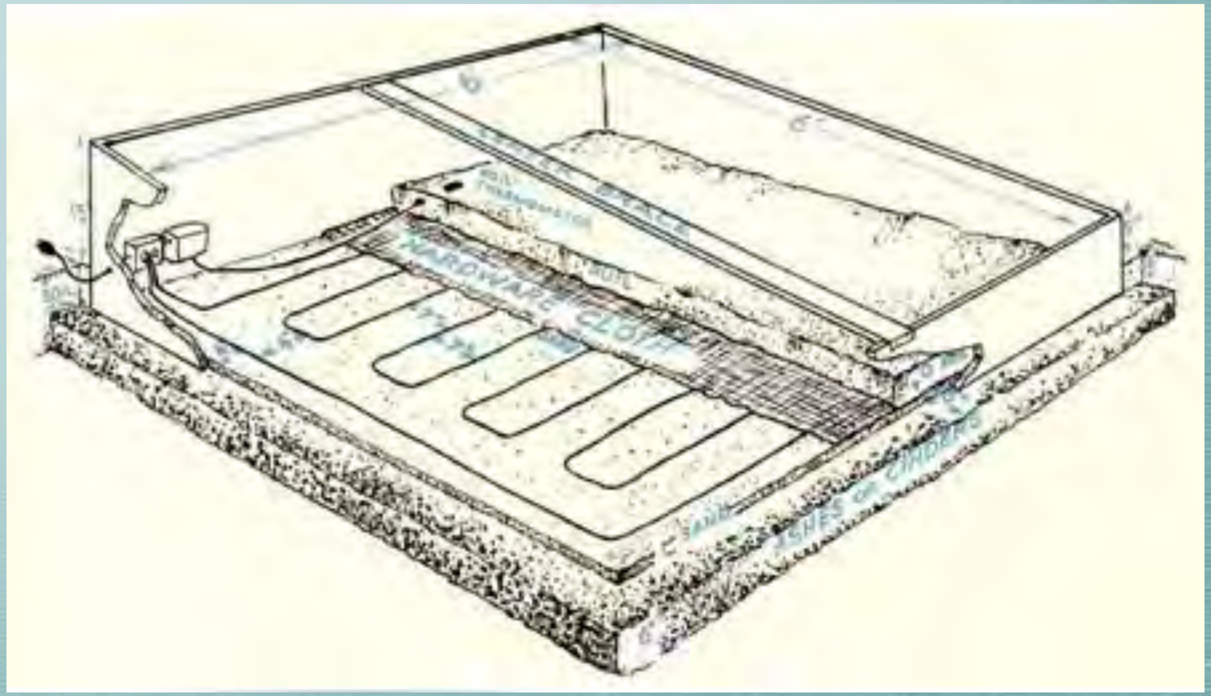
- generally arched
- provides light and temperature control
- used to overwinter hardy crops (broccoli, cabbage, etc, or start hardy spring crops
- may be covered with polyethylene film, shade fabric or have no covering during warm season
- when a supplemental heater is added, the structure is often referred to as a **“greenhouse”**

2. Cold Frames

- Similar to a hoop house. May be partially set into ground.
- Typically not as tall
- Generally used for overwintering hardy spring crops or provide protection to bulb crops
- No heating or cooling systems.

3. Hot Beds

- some type of heat source provides more control over temperature
- heat source: boiler, electrical, incandescent light bulbs, composting manure
- mostly used for starting plants in early spring



4. Shade Houses

- structures covered with fabric made of polypropylene, cotton, plastic or other material to partially exclude light
- some materials are aluminized so that the light is actually reflected away from the structure
- typically shading materials exclude 20-60% of light
- typically do not have heating or cooling systems
- used for cut flowers, foliage plants and nursery stock.

5. Typical Greenhouse Designs

Figure 1. Freestanding hobby greenhouse styles

Quonset

Based on arched roof.

A-Frame

Usually a series of supporting trusses that for the roof and gables.

Ridge and furrow or Gutter Connected

- Two or more greenhouses built side by side and connected to each other.
- Most commercial greenhouses use a gutter connected design.
- Allows for larger, unobstructed interior than stand-alone houses.

Added on to a building

- Can be added to the south side of an existing structure.
- Can utilize heat from the structure when needed.
- May provide seasonal heat the building to which it is connected.
- Commonly added to barns, outbuildings our houses.

Roll-up Walls

- Allow for more precise temperature control.
- Used to mitigate heat build-up on sunny days.
- Can be useful in providing

Structural Design Considerations

A structure must meet the building codes for a specific location.

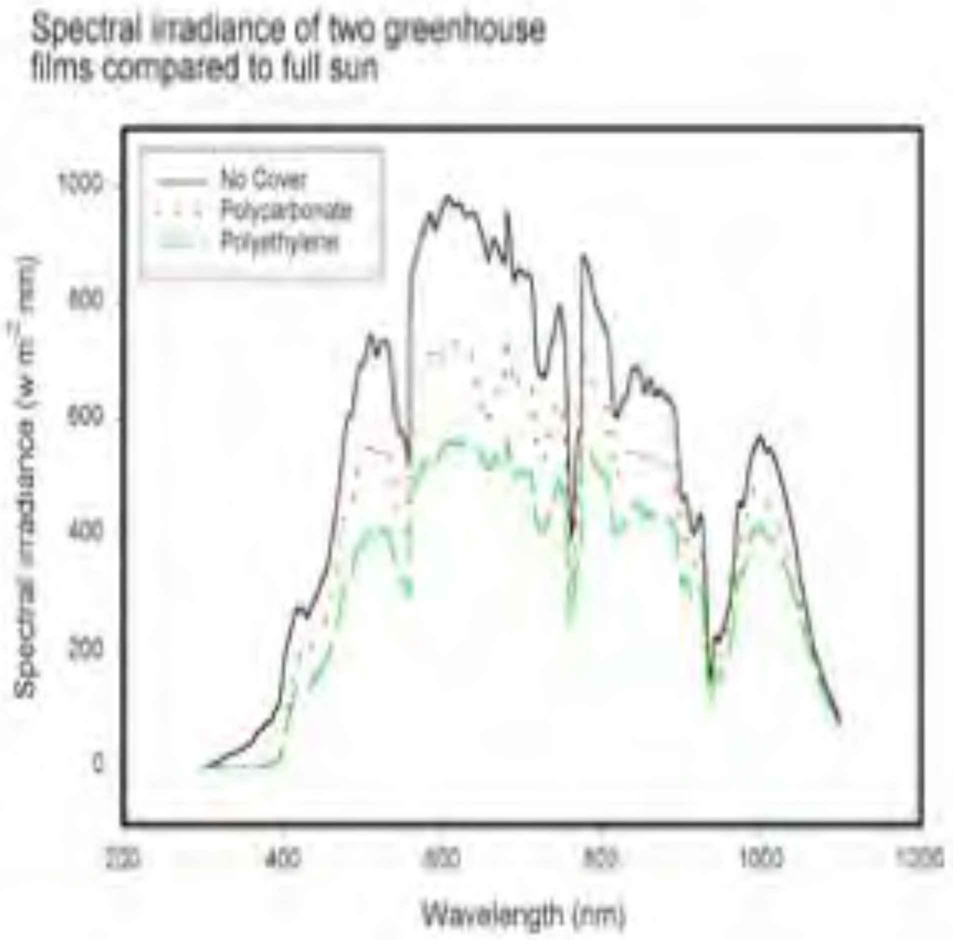
Make sure you talk to your local inspectors.

Structural Design Considerations: Load

- Dead load includes: weight of structure, framing, glazing, permanent equipment, heating and cooling units, vents, etc.
- Live load includes: weight of people working on roof, hanging plants, snow loads, wind loads.
- Most greenhouses are required to support an 80 mph wind.
- Required snow load is based on expected accumulation, roof slope and on greenhouse design.

Structural Design Consideration: Light

- The objective is to maximize light transmission. Thus, material usage and the framing should be take this into account.
- Greenhouses should be built far away from trees or other structures that could shade the greenhouse.



Structural Design Consideration: Water

- Irrigation should be thought about before construction begins.
- Consider plumbing in a frost-free hydrant within the structure.
- Water-catchment systems can catch and store water for later use in areas with low rainfall.

http://www.youtube.com/watch?feature=player_detailpage&v=3j09zP84boM

Choose a greenhouse for your needs

Seed starting for home garden? **Cold frame or hot bed**

Seed starting for a small farm? A small, heated **greenhouse**

Winter vegetable production? A large heated **greenhouse or unheated hoop house**

Season extension? **Unheated hoop house**

Greenhouse growing tips: Spring crops

Common greenhouse crops: Carrots, radishes, turnips, spinach, kale, lettuce, arugula

Not usually grown in greenhouse: new potatoes (too slow), peas (grow too tall)

Greenhouse growing tips: Spring crops

Seeding schedule for Northern climates:

Carrots: mid-Dec to March
Turnips and kale: March
Radishes, lettuce, spinach, arugula: Jan-April

Greenhouse growing tips: Spring crops

Tip: Because of close spacing, overhead irrigation is recommended

Tip: On nights that will get below freezing, suspend a mid-weight row-cover one foot above crops

Greenhouse growing tips: Summer crops

Common greenhouse crops for summer production: peppers, tomatoes, cucumber, eggplant, basil

Greenhouse growing tips: Summer crops

Transplant schedule for Northern climates (6 to 8 weeks from seeding):
peppers/eggplant: April (heated greenhouse), May 15 (unheated greenhouse)
tomatoes: March 15 (heated), April 15 (unheated)
cucumber/basil: May 1 (heated), May 15 (unheated)

Greenhouse growing tips: Summer crops

Tip: crops will grow taller in greenhouses, so consider trellising them to rafters in the greenhouse

Tip: Summer crops often do not like wet leaves, so irrigate with drip tapes

Greenhouse growing tips: Fall/winter crops

Common crops for Fall/winter greenhouse: carrots, pac choi, spinach, lettuce, turnips, radish, arugula, kale

Greenhouse growing tips: Fall/winter crops

Seeding schedule for Northern climates:

Carrots: late-July
Turnips, pac choi, kale: late-July to late-August
Radishes, lettuce, spinach, arugula: Sept 15-Oct 30

Greenhouse growing tips: Fall/winter crops

Tip: In heated greenhouses, set heaters to 32 degrees F

Tip: In unheated greenhouses, suspend mid-weight row covers one foot above crops

Tip: Water less in the winter to avoid mildew and mold

Self-Review Questions

- What types of structures for growing plants are best for season extension?
- What plants are best in an unheated hoop house in the spring? And in the summer?
- What types of load on the structure need to be taken into account?

Resources

http://faculty.yc.edu/ycfaculty/ags250/week04/greenhouse_types_and_structures/Greenhouse_types_and_structures_print.html

Eliot Coleman, *Winter Harvest Manual*, 2012

Eliot Coleman, Four-Season Harvest, 1999

The Hoophouse Handbook, Growing for Market, 2006

DIRECT SEEDING

LEARNING OBJECTIVES

1) The learner will gain a solid understanding of direct sowing.
2) The learner will be taught which kind of crops should be direct sown.
3) The learner will gain an understanding of the environmental needs for seeds, in order to sprout and grow.
4) The learner will be taught how to create an adequate environment for seeding.
5) The learner will be taught how to care for the crop after planting.

DIRECT SEEDING

Direct seeding is a term that describes a seeding method. The direct seeding method involves sowing seeds directly into the soil that the plants will later mature in.[1] Some of the advantages to direct seeding are that the grower will not need to transplant their crop at a later time. Plants that have been sown directly into the soil will develop faster than plants which have been transplanted.[1] There is less risk for plants when they have been directly seeded into the soil, because transplanting can be stressful to plants in many ways.[2]

Perhaps the greatest thing to consider in choosing whether or not to direct seed a crop is the type of root that the particular crop has. Some plants have roots that are intolerant to transplanting and these roots are called taproots. Plants with taproots should almost always be directly seeded into the soil that they will mature in. [2]

TANSPLANTING TAPROOTS

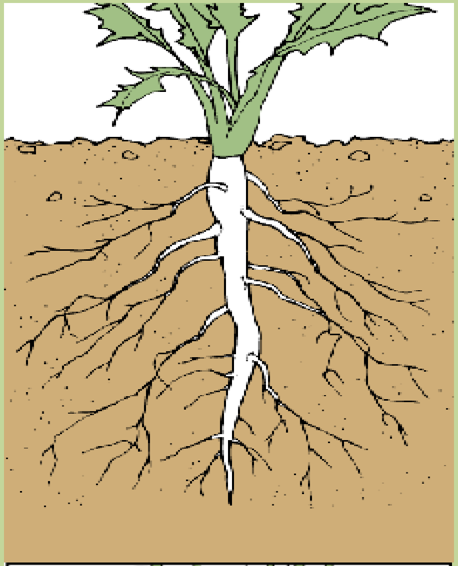
If a grower does have the need to start a taproot crop from seed with the intention of transplanting, there are a couple things that the grower should keep in mind.

1) Taproot crops have roots that grow downward rapidly. They will quickly outgrow a shallow container. The young taproots are fragile and they should be transplanted as early as possible.[2]

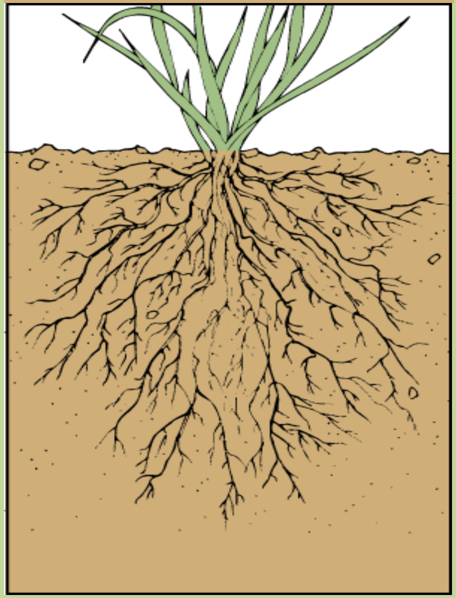
2) For the best success in transplanting taproot crops, plant several seeds together to create a cluster of seedlings. After the seedlings have grown their first set of leaves, transplant the entire cluster together, leaving the soil around the taproots.[3] By transplanting the cluster of seedlings with their surrounding soil, the seedlings root's will be less likely to be damaged. The cluster of seedlings will need to be thinned after the second set of leaves have grown in order to provide proper spacing for the plants.[4]

SELECTING CROPS TO DIRECT SOW

Taproots can be identified by their solid root structure. Some common examples of taproots are dandelions, carrots, beets, turnips and radishes. Taproots are fragile and taproot crops will always benefit from being directly seeded into the soil that the plant will mature in.[4]



Fibrous roots can be identified by numerous, thin roots that grow downward and away from the plant. Generally, fibrous roots are more shallow than tap roots.[5] Plants that have fibrous roots can be transplanted or they can be sown directly into the soil that they will mature in.



COMMON DIRECT SOWN CROPS

Salad greens
Sunflowers
Cucumbers
Radishes
Turnips
Grasses
Melons
Carrots
Potato
Squash
Beans
Beets
Corn
Peas

SEED GERMINATION

Seed germination is a term that describes the process of a seed producing a sprout, or seedling. Generally speaking, there are three environmental requirements for a seed to germinate. Seeds need water, temperature and oxygen in order to produce and grow a sprout.[6]

MOISTURE NEEDS FOR GERMINATION

Water moisture is needed for seeds and it is used in a process called inhibition. During inhibition, the seed uses the absorbed water to swell the embryo inside the seed, which breaks open the shell.[7] The growing embryo continues to use water, along with oxygen, to convert the food that was stored in the seed into energy for the emerging sprout. Most seeds require enough water to wet them, though never too much water as to soak them. It is important not to soak the seeds after the seed shell has broken. The excess water will deprive the embryo of oxygen and prevent the embryo from creating energy from it's stored food. [6]

SEED GERMINATION

MOISTURE NEEDS FOR GERMINATION

ACCELERATING SEED GERMINATION

Seeds that have hard seed coating, like peas or beets, will take longer to germinate than seeds with a thin coating. A grower can reduce the amount of days needed for a seed to germinate by soaking the seeds in water. Seeds can be drown if they are soaked for too long. Most garden vegetable seeds can soak for 12 to 24 hours but never more than 48 hours, as they will drown.[8] Some gardeners use a bowl of hot water that they immerse the seeds in, and then allow the water with the seeds in it to cool overnight. Another technique to speed up germination is to slightly acidify the hot water with lemon juice, tea or coffee. The acidic hot water will help the seed absorb water faster. [8]

SEED GERMINATION

TEMPERATURE NEEDS FOR GERMINATION

The soil temperature that is required for seeds to germinate can vary greatly between plant species. Generally, vegetable crops will germinate when the soil is between 75-90 F (24-32C).[6] Many crops, like spinach or radishes, are called winter crops. Winter crops will germinate at soil temperatures as low as 40 F. If a grower sows seeds into the soil that is not warm enough, the time until germination will be extended until the soil warms to a temperature that is appropriate for that particular crop.[7]

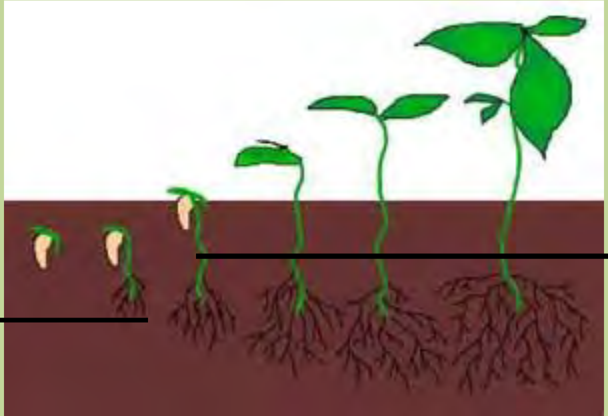
It is wise to wait until the soil temperature is warm enough for the crop, as the seed will wait until the temperature rises before germinating.[6][7] During the waiting time; the seeds are vulnerable to disease, insects, fungi and animals.

SEED GERMINATION

OXYGEN NEEDS FOR GERMINATION

During the inhibition process, the embryo in the seed uses oxygen, along with an enzyme to break down it's food storage into energy.[6][7] A grower should allow oxygen to the emerging seed by keeping the soil wet but not waterlogged. It is also important to not plant the seed in compacted soil because the embryo's oxygen supply is in the tiny air pockets within the surrounding soil.[6] The embryo will continue to use oxygen and water for energy until it emerges from the soil and receives sunlight. After the sprout receives sunlight, the sprout begins to use carbon dioxide and sunlight to create energy.[6]

Oxygen is used for energy while the embryo is below the surface of the soil.



Once the sprout emerges from the soil, it will begin to use sunlight and carbon dioxide for energy.

PREPARING THE SOIL FOR SEEDING

TILLING

Tilling is a term that describes the process of breaking apart the soil for planting. The main benefits of tilling the soil are creating air pockets for root growth, while also supplying oxygen for the emerging spouts. Tilling can be useful for spreading compost, mixing in soil amendments and leveling growing spaces.[9][10] Another benefit of tilling the soil is weed removal because tilling will uproot weeds and mix them into the soil.[10]

Most growers will till the soil at the beginning of the growing season, before planting, in order to mix air into the soil.[9] Some growers will till throughout the growing season, in between the crop rows, in order to kill unwanted weeds.[10]

PREPARING THE SOIL FOR SEEDING

TILLING

There several methods for tilling the soil. The best method to use should be determined by the size of your growing space. In large growing spaces, like a field or pasture, a tractor or horse drawn tiller is highly recommended.[10] Both, tractors and horses, are expensive to buy and maintain and they are not always practical for growers that have small growing areas.

Most growers that have a small growing area use a push tiller because they are cheaper to purchase or rent, and they are maneuverable in a smaller growing areas.[9][10]

Here is a video that shows a horse drawn tiller.

Here is a video that shows a tractor drawn tiller.

Here is a video that shows a push tiller.

PREPARING THE SOIL FOR SEEDING

TILLING NEW GARDEN BEDS

Tilling a new garden bed requires deeper tilling than a garden that has already been established.[10] A new garden bed should be tilled to a depth of 8 to 10 inches. After tilling to that depth, 4 to 6 inches of compost should be added to the growing area by spreading it evenly.[10] That compost should then be tilled into the soil to a depth of 3 inches.[9]

TILLING EXISTING GARDEN BEDS

Existing garden beds should not be tilled more than 3 inches deep.[9] There are many organisms in the soil that benefit the plants we grow. These organisms like bacteria, fungi and worms, are harmed with deep tilling as they are exposed to an environmental condition that they are intolerant to.[10]

PREPARING THE SOIL FOR SEEDING

GREEN MANURE

Green manure is a term that describes a crop that is grown with the intention of tilling that crop into the soil.[12] The green manure crop is often a legume variety of plant, like soybeans, which in naturally rich in nitrogen.[11][12] When the green manure is tilled into the soil, the plants that have been tilled into the soil will decompose and provide additional nitrogen to the soil for the next crop grown afterwards.[11][12]

Using green manure to increase soil fertility is a very old practice that been used for hundreds of years.[12]

Here is a video that describes green manure.

PREPARING THE SOIL FOR SEEDING

AN ALTERNATIVE TO TILLING

Some growers prefer not to till their soil after their garden has been established. An alternative method to tilling the soil annually is to build the soil up by adding thick layers of compost onto the growing area.[13] The alternative to tilling method is called the no-till method. This method requires a lot of resources, like composted manure, and it is not always practical for growers who do not have access to cheap or free compost.

Here is a video that shows a compost layering method as an alternative to tilling.

PREPARING THE SOIL FOR SEEDING

AN ALTERNATIVE TO TILLING

In using the no-till method or any other tilling method, it is very important to only add compost that has been heated to a minimum of 140 F degrees. The heat will kill any unwanted seeds present in the compost, like grass seeds. The compost should not be heated above 160 F degrees though, because the beneficial bacteria that further decomposes the compost material will die.[14] In order to determine the temperature of the compost, a grower will need to use a long soil thermometer.

Here is a video that shows how to use a soil thermometer.

SOIL AMENDMENT

Soil amendment is a term that is used to describe the process of adding materials to a growing area, in order to optimize the soil's potential for growing plants. [15] Some soil amendments increase soil fertility, change soil acidity or they can change the soil's composition.[13][15] Some soil amendments are used to change the composition of the soil itself, in cases of sandy or clay ridden soil. Most of these amendments are organic material that is worked into the soil. By working the material into the soil, often by tilling, a grower can create an optimized soil that has small air pockets in it. Plants need the loose soil with air pockets in order to grow.[13][15] Organic material, like peat moss or composted leaves, works well for creating air pockets in the soil. Generally, soil amendments are tilled or raked into the top 3 inches of soil. It is possible to over amend the soil when using fertilizers.[15]

Here is a video that shows amending soil by using compost.

Here is a video that shows using organic amendments.

IRRIGATION

Irrigation is a term that describes a method for giving seeds and plants adequate water artificially, not relying on rainfall.[16][17] Irrigation can be in the form of flood irrigation, which uses deep trenches to channel flood water. Irrigation can also be localized, which we are more familiar with. Localized irrigation is when we apply water to the soil around and on top of the seeds or plants.[16][17]

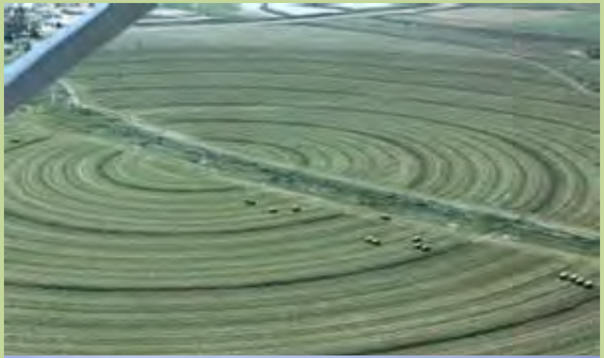
CHOOSING THE RIGHT IRRIGATION

The greatest factor in choosing a system of irrigation is the size of your growing area.[16] [17] Large growing areas, like fields, require a large irrigation system that can pump ground water or transport water from a distance. Growers that have smaller areas, often less than an acre, find water sprinklers or drip irrigation to be more practical.[17] Greenhouses and small gardens are often watered with a garden hose and nozzle or drip irrigation.[16]

IRRIGATION

CHOOSING THE RIGHT IRRIGATION

Large growing areas, like several acre fields, require large irrigation systems during very dry or hot periods throughout the growing season. [17] They are quite expensive and they are only practical for large growing operations.



Center pivot irrigation systems irrigate large areas in circular pattern. Here is video that shows a circle pivot irrigation system.

Lateral move irrigation systems work well for large, square or rectangular fields. Here is a video that shows a lateral move irrigation system.

IRRIGATION

CHOOSING THE RIGHT IRRIGATION

Most growers that have a growing area of a few acres or less will use moveable sprinklers or a drip irrigation system. [16]

Moveable sprinkler systems are not very expensive to purchase. They are also not very efficient because they waste water when compared to drip irrigation. [16]

IRRIGATION

CHOOSING THE RIGHT IRRIGATION

Drip irrigation systems are very efficient in water conservation. They work through a network of pressurized waterlines, valves and sometimes nozzles. Drip irrigation systems will drip water, through a perforated water line or nozzle, directly where it is needed for the plant; the root zone.[18][19] The root zone of a plant lies directly underneath the plant and it is the area that needs water. In a fibrous root system, the root zone is usually the diameter of the plant itself.[19] By watering the root zone only, a grower can avoid washing away nutrients from their soil, while saving money from not overwatering. [18]

Here is a video that shows drip irrigation.

DIRECT SEEDING METHODS

Direct seeding by hand

There are different methods for direct seeding.[1] Some methods for direct seeding use commercial equipment like automated seed planters for very large fields. Other methods use hand tools, including our hands, for direct seeding. In choosing best method for direct seeding, the grower should consider the size of their crop production area and their available resources. [1]

Direct seeding by hand involves using hand tools like a shovel or hoe to create a trench or hole to place the seeds into.[20] This method of hand sowing is time consuming and it not always practical for the commercial grower. Growers who have small growing areas will often choose to direct seed many of their crops by hand because it is more practical for their small growing space. [1]

DIRECT SEEDING METHODS

Direct seeding by hand

Here is a four step method for direct seeding by hand

1. Open a trench with your fingers or a hand tool to a depth of approximately two times the diameter of the seed.
2. Sow two or three seeds for each desired plant. A few of the seeds will not sprout. Of the seeds that do sprout; they can be thinned and the extra plants can be moved to a location where many of the seeds within a particular area did not sprout.
3. Cover the seeds and level the trench.
4. Gently tamp down the soil with your hand or the head of a rake to assure soil-to-seed contact.

[Here is a direct sowing by hand video.]

DIRECT SEEDING METHODS

Direct seeding by using a push seeder

Many small farmers choose to use a push seeder.[20] The push seeder allows for small farmers to seed a large area in a small amount of time. Another advantage to using a push seeder is that crops do not need a lot of thinning.[21] Most push seeders are equipped with changeable seed plates. These plates are inside of the push seeder and they allow for a predetermined depth and spacing for different seed varieties. Generally, push seeders will drop the seeds into a trench that the seeder makes.[21] The push seeder will then cover the seeds with soil that it then presses down.

[Here is a video that shows direct sowing by using a push seeder.]()

DIRECT SEEDING METHODS

Direct seeding through the broadcast method

The broadcast method of planting seeds involves tossing the seeds evenly over a large area.[1] The broadcast method works well for planting grasses or cover crops in large areas like fields and pastures.

1) Determine the application rate using references such as crop-spacing charts or the seed packages.
2) Broadcast evenly over surface of soil by hand, with a push spreader or with a mechanical spreader.
3) Cover lightly with a mixture of 50% garden soil and 50% compost.

[Here is a video that shows broadcast seeding by hand.]

DIRECT SEEDING METHODS

Direct seeding with a broadcast seed spreader

Broadcast seeding with the use of a walk behind seed spreader has many advantages to broadcast seeding by hand.[22] One of the advantages is that a walk behind seed spreader will give the grower an even spread of seed on the surface of the ground. Most walk behind seed spreaders have an adjustable gate that lets the seed pass through it. [22] The operator of the walk behind seed spreader can adjust the gate to compensate for the varying walk speed of the operator, allowing for a constant application of seeds.

Here is a video that shows broadcast seeding by use of a [walk behind broadcast seed spreader.]()

THINNING A DIRECT SOWN CROP

Seeds that have been sown directly into the soil often require sowing more seeds into the soil than the soil in a particular place can support. Extra seeds are sown into the soil because some of the seeds are expected to not sprout.[23] Many of the seeds that do sprout can be eaten by insects, birds or animals. The sprouts are also susceptible to a heavy rain that can wash them away, and they are susceptible to diseases like harmful fungus or mold.

Thinning is a term that is used to describe a method for removing a portion of an unwanted crop.

Thinning is used to give an adequate space between plants. [4][23] By having an adequate space between plants, a grower can have an optimal crop yield.[4]

[Here is a video that shows thinning.]

RECORD KEEPING

Record keeping for a grower is important. The information to record will depend on the growing operation, because they are not all the same.[25] Some growers have hired help and they must record labor hours as well as information about the crop. Many growers are farming for a profit and they should record expenses, like equipment, along with labor hours.[24] All growers should record what amendments were added to the soil and when, including concentrations.[24][25] Some growers record crop yields to compare with past harvests. They can then predict how that crop produce in the future.[25] Many growers will use field notes that are hand written. These are often taken when working with the crops, checking for insect damage or monitoring weed encroachment.

ASSESMENT QUESTIONS

1) What is direct seeding? How is it different than transplanting?
2) What kind of plant root system benefits from being direct seeded? Taproots or fibrous roots?
3) How should taproots plants be transplanted, if the need arises?
4) What environmental factors do seeds need in order to sprout?
5) What should be done to loosen the soil before planting?
6) How far down should the soil be loosened for a new growing area?
7) How far down should the soil be loosened for an existing growing area?
8) What is green manure? How does it increase soil fertility?
9) What is an alternative method to tilling the soil?
10) How hot should compost be in order to kill unwanted seeds?
11) What are soil amendments? How are they used and for what purposes?
12) What factors should you consider in choosing the right irrigation for your growing area?

ASSESMENT QUESTIONS

13) How is direct seeding by hand different than direct seeding using machines?
14) What is broadcast seeding? What are the benefits of broadcast seeding?
15) How do you thin a crop? What does thinning the crop do?
16) What records should growers keep?

REFERENCES

[6] Albert, S. (2013, February). *Seed germination requirements*. Retrieved from Harvest to Table: http://www.harvesttotable.com/2013/02/seed-germination/

[9] Anderson, M. (2012, April). *How to till your garden properly*. Retrieved from Do it yourself: http://www.doityourself.com/stry/till-garden-properly#.Ub80vZHD-1s

[1] Bareja, B. G. (2011, March). *Methods of planting crops in the farm*. Retrieved from Crop Farming Review: http://www.cropsreview.com/planting-crops.html

[5] Bareja, B. G. (2011, April). *Taproot and fibrous root systems, specialized roots*. Retrieved from Crop farming Review: http://www.cropsreview.com/fibrous-root.html

[23] Beazley, M. (2012, September). *Start growing: Seed starting*. Retrieved from Mother Earth News: http://www.motherearthnews.com/organic-gardening/sowing-and-growing-ze0z1209zbla.aspx?PageId=1#ArticleContent

REFERENCES

[4] Cartright, J. (2009, August). *Thinning your vegetable garden*. Retrieved from Ezine Articles: http://ezinearticles.com/?Thinning-Your-Vegetable-Garden&id=2713006

[25] Chait, J. (2013). *Record keeping tips for an organic farming business*. Retrieved from Organic Business: http://organic.about.com/od/cropsfarming/tp/Record-Keeping-Tips-For-An-Organic-Farming-Business.htm

[18] *Drip irrigation*. (2013, January). Retrieved from Washington State University: http://smallfarms.wsu.edu/crops/irrigation/index.html

[19] Evans, R., Cassel, K. D., & Sneed, E. R. (1996, June). *Soil, water, and crop characteristics important to irrigation scheduling.* Retrieved from Department of Biological and Agricultural Engineering: http://www.bae.ncsu.edu/programs/extension/evans/ag452-1.html

[11] *Green manures*. (2013, January). Retrieved from Garden Organic: http://www.gardenorganic.org.uk/factsheets/gs3.php

REFERENCES

[17] Harrison, K., & Tyson, A. W. (2012, Febuary). *Factors to consider in selecting a farm irrigation system*. Retrieved from The University of Georgia: http://www.caes.uga.edu/publications/pubDetail.cfm?pk_id=6979

[3] Jacobs, K. L. (2011, April). *Transplanting winter-sown seedlings*. Retrieved from A Garden for the House: http://www.agardenforthehouse.com/2013/03/transplanting-winter-sown-perennials-updated-bumped/

[24] *Keeping good records*. (2013). Retrieved from Cornell University: http://nebeginningfarmers.org/farmers/achieving-profitability/managing-your-finances/

[7] Kennell, H. S. (2012, April). *Seed Germination*. Retrieved from Gardening in Western Washington: http://gardening.wsu.edu/library/vege004/vege004.htm

[16] Lawrence, A. (2010, January). *How to irrigate a garden*. Retrieved from Gardenguides.com: http://www.gardenguides.com/81939-irrigate-garden.html

REFERENCES

[13] *No-till farming pros and cons*. (1984, May). Retrieved from Mother Earth News: http://www.motherearthnews.com/homesteading-and-livestock/no-till-farming-zmaz84zloeck.aspx?PageId=1#axzz2WVFF9WcM

[12] Pieters, A. J. (1927). *Green manuring.* Retrieved from Sustainable Farmer: http://sustainablefarmer.net/pdflibrary/library-greenmanuring.pdf

[8] Rhoades, H. (2013, January). *How to soak seeds before planting and the reasons for soaking seeds*. Retrieved from Gardening Know How: http://www.gardeningknowhow.com/garden-how-to/seeds/soaking-seeds.htm

[21] Sanders, C. D. (1994, July). *Precision seeding for vegetable crops.* Retrieved from North Carolina State University: http://www.ces.ncsu.edu/depts/hort/hil/hil-36.html

[2] Smith, T. P. (2010, April). *Direct seeding vegetable crops*. Retrieved from Ezin Articles: http://ezinearticles.com/?Direct-Seeding-Vegetable-Crops&id=4194960

REFERENCES

[22] *The seed spreader explained*. (2013). Retrieved from Do It Yourself: http://www.doityourself.com/stry/the-seed-spreader-explained#.UcCvMZHD-1s

[14] Trautmann, N. (1996). *Compost Physics*. Retrieved from Cornell University: http://compost.css.cornell.edu/physics.html

[20] Vanderlinden, C. (2013). *How to direct sow garden seeds* . Retrieved from Organic Gardening: http://organicgardening.about.com/od/startinganorganicgarden/a/directsowing.htm

[10] Wander, M., & Gruver, J. (2011, September). *Tillage*. Retrieved from Soil Quality: http://soilquality.org/practices/tillage.html#why

[15] Whiting, D., Card, A., Moravec, C., & Wilson, C. (2011, December). *Soil amendments.* Retrieved from Colorado State University: http://cmg.colostate.edu/gardennotes/241.pdf

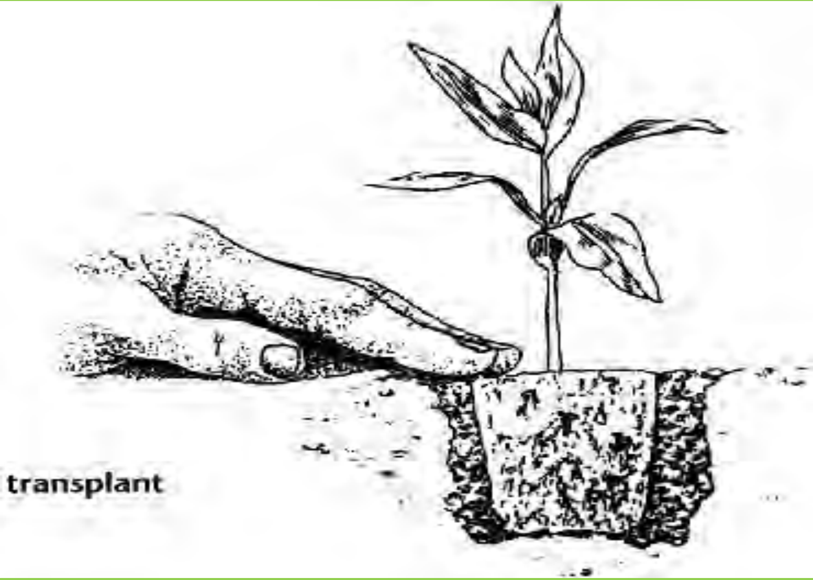
Transplanting

Why Transplant?

Transplants offer several advantages to the grower.

We use transplants to lengthen our growing season. In the Midwest this is especially important with plantings that require long growing seasons. By starting our seedlings in a greenhouse we gain valuable growing time; bringing produce to market earlier when profit margins are at their best. Of course not all plants respond well to transplanting (root systems have a big part to do with this) and even the ones that do need special care and attention for success.

Controlled environments, like greenhouses, give farmers the ability to start seedlings early and use transplants in the farming enterprise.



Greenhouse Advantages

1. Greater Climate Control

2. Intensive rather than extensive management of seedlings
    - Pest management
    - Disease management
    - Irrigation needs

3. Rapid crop successions

The root nature of a plant is a good indicator if it will be a successful transplant. The fibrous root system (spread root system) is typical of plants grown for transplanting (vs tap roots which are more typically directly seeded).

Transplants allow for greater control over specific density of crops. Spacing is more exact and controlled.

Seedling pre-treatment necessary for successful transplanting

The soil mix that seedlings are grown in should be fertile and have water retention capabilities. Pre-mixed starter soils with the OMRI label are acceptable alternatives to mixing your own. (see greenhouse module)

Moisture in flats should be 50%-75% of field capacity and in cells at field capacity.

Soil Moisture Chart

SOIL MOISTURE LEVEL (% OF FIELD CAPACITY)	COARSE (SAND)	LIGHT (LOAMY SAND, SANDY LOAM)	MEDIUM (FINE, SANDY LOAM, SILT LOAM)	HEAVY (CLAY LOAM, CLAY)
0–25% No available soil moisture. Plants wilt. Irrigation required. (1st range)	Dry, loose, single grained, flows through fingers. No stain or smear on fingers.	Dry, loose, clods easily crushed and will flow through fingers. No stain or smear on fingers.	Crumbly, dry, powdery, will barely maintain shape. Clods, breaks down easily. May leave slight smear or stain when worked with hands or fingers.	Hard, firm baked, cracked. Usually too stiff or tough to work or ribbon[1] by squeezing between thumb or forefinger. May leave slight smear or stain.
25–50% Moisture is available, but level is low. Irrigation needed. (2nd range)	Appears dry; will not retain shape when squeezed in hand.	Appears dry; may tend to make a cast[2] when squeezed in hand, but seldom will hold together.	May form a weak ball[2] under pressure but will still be crumbly. Color is pale with no obvious moisture.	Pliable, forms a ball; will ribbon but usually breaks or is crumbly. May leave slight stain or smear.
50–75% Moisture is available. Level is high. Irrigation not yet needed. (3rd range)	Color is darkened with obvious moisture. Soil may stick together in very weak cast or ball.	Color is darkened with obvious moisture. Soil forms weak ball or cast under pressure. Slight finger stain, but no ribbon when squeezed between thumb and forefinger.	Color is darkened from obvious moisture. Forms a ball. Works easily, clods are soft with mellow feel. Will stain finger and have slick feel when squeezed.	Color is darkened with obvious moisture. Forms good ball. Ribbons easily, has slick feel. Leaves stain on fingers.
75% to field capacity (100%) Soil moisture level following an irrigation. (4th range)	Appears and feels moist. Color is darkened. May form weak cast or ball. Will leave wet outline or slight smear on hand.	Appears and feels moist. Color is darkened. Forms cast or ball. Will not ribbon, but will show smear or stain and leave wet outline on hand.	Appears and feels moist. Color is darkened. Has a smooth, mellow feel. Forms ball and will ribbon when squeezed. Stains and smears. Leaves wet outline on hand.	Color is darkened. Appears moist; may feel sticky. Ribbons out easily, smears and stains hand, leaves wet outline. Forms good ball.

1/16/13

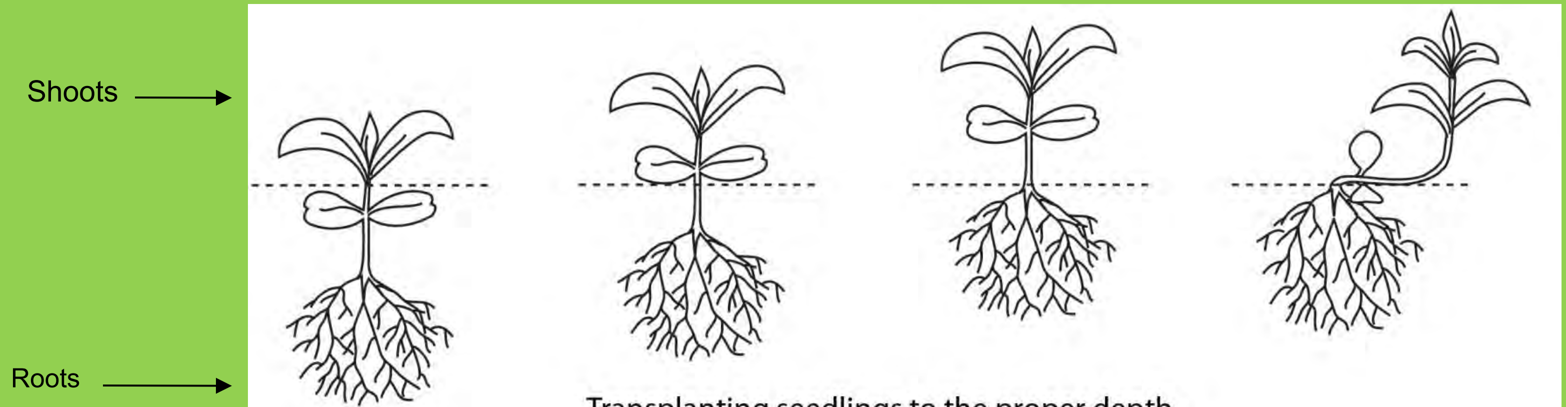
Assess Plant, Soil, and Environmental Conditions Prior to Transplanting

Assessing the Plant for Transplanting Readiness

Plants should show second set of true leaves (shoot development).

Root Knit should be present in cells or roots should fill allotted space in flats(blocks).

[Soil Blocking Video]



Transplanting seedlings to the proper depth

Transition from Greenhouse to Field

Hardening off period: Hardening off reduces amount of stress for start by gradually increasing amount of exposure to outside elements. Hardening off should start up to 21* days prior to acceptable field transplant date.

Move starts to cold frame 3-21* days before they are ready to enter the field, cover off in the day and cover on at night

Leave the starts exposed to the elements for a half hour to an hour longer each consecutive day

Finally, leave them exposed all day and all night the final days.

*Hardening-off period should increase in duration with increased differential between field and greenhouse conditions.

Asses Field or Garden Soil Conditions Before Transplanting

- **Moisture**
- **Cultivation**
- **Environmental Conditions**

Moisture

Soil Moisture for optimum conditions when transplanting should be 50-75% of field capacity

Cultivation

Extensive secondary cultivation is needed for transplants with small, weak or insufficient root systems (i.e. beets or carrots) much like direct seeding.

Course secondary tillage for large, vigorous, and resilient transplants (e.g. tomatoes and peppers) is fine.

[2nd method video]

[Setting up your garden]

Consider using no –till methods for establishing gardens/plots.

[No-till bed preparation]

Environmental Conditions Favorable for Successful Transplanting

Optimal conditions in the field will add to the success of your transplants by reducing shock and helping the seedlings to take root quickly.

The best field conditions for Transplanting seedlings include:

- Low light levels
- Low Temperatures
- Little or no wind
- High humidity

The best time to transplant any start is in the cool of the evening. This allows the plant a nice buffer to become acquainted with its new surroundings before dealing with a hot sun.

Transplanting Starts

Gather your tools;

- Mature seedlings
- Hand trowel
- Watering wand
- Dibble
- String and stakes

Optional transplanting tools;

- Hatfield transplanter (Johnny's seeds) http://www.johnnyseeds.com/MediaPlayer.aspx?VideoID=21&source=JSSVideos
- Pull behind mechanisms http://youtu.be/gMSpN0E8_H8

Starts should be thoroughly watered before transplanting. This greatly reduces shock. Using a weak fish emulsion solution just prior to transplanting helps reduce shock.

1 sand

LIQUID FERTILITY

Using watering can, per gallon of water:

1/4 cup liquid fish emusion

1/2 tsp. Kelp powder

Using foliar sprayer:

Also add 1/4 tsp. sticker-spreader (surfactant), added last into the tank to avoid excess foaming (see Resources section)

Mix ingredients in a little water in a bucket, then pour into a 3-gallon backpack sprayer and fill to the line with more water. For basal applications, remove spray nozzle.

Fertigation is best done in the early morning or in the evening.

Plant spacing considerations;

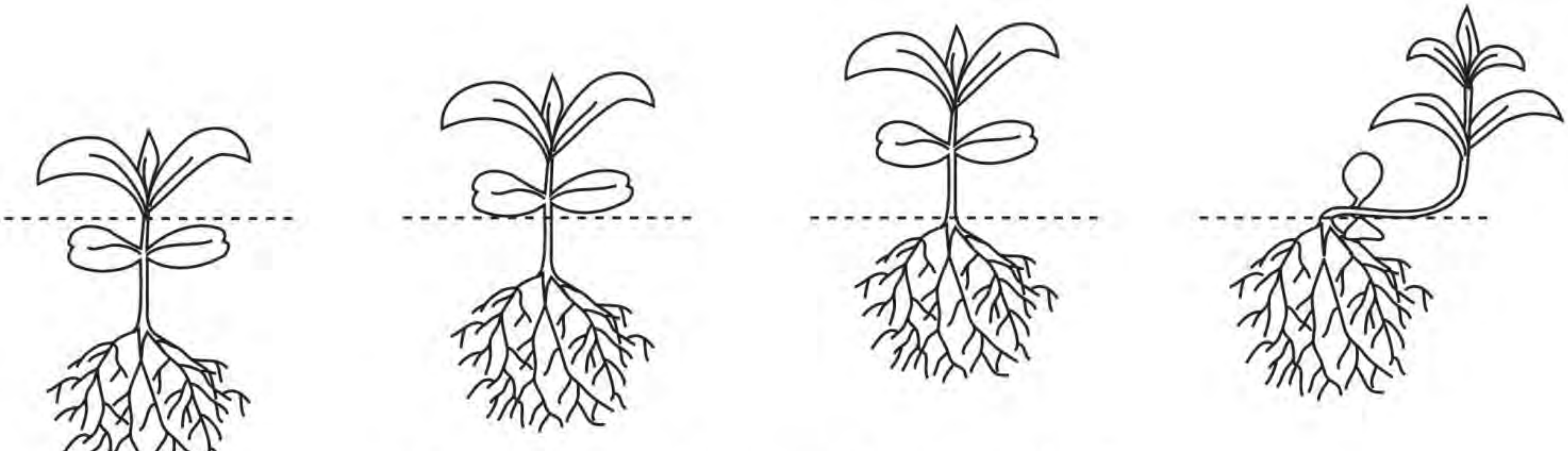
- Row planting should be wide enough to accommodate drip irrigation ribbon and cultivation tool.
- Fertile soils can accommodate denser plantings where as infertile or degraded soil plant density should be low.
- How large will the root system and plant shoots be at maturity.
- Is the crop susceptible to disease; Increasing the spacing to assure better air circulation can cut down on fungal pathogens(early and late blights).
- By increasing crop density in certain cut flowers, the bloom shaft length may be increased. Increasing spacing often results in greater numbers of shorter bloom shafts.
- Use available references and seed packaging to help determine best spacing.

Keep starts in shaded area until they enter the ground

When pulling apart individual soil blocks or removing starts from trays, carefully separate the intertwined root growth, causing as little trauma as possible, while still remaining efficient.

Do not expose tender root systems to direct sunlight (as little as 15 seconds of exposure can kill roots)

Depth Of Planting



Transplanting seedlings to the proper depth

Most crops should be planted to the cotyledons (immature leaf set). However, the Solanaceae family (tomatoes, peppers,eggplants) and Brassicaceae family (broccoli,cabbage,cauliflower, brussel sprouts, etc) are adventitious rooters and can be buried to the first true leaves (or deeper).

Take special care to insure the top of the soil block or cell being planted is covered with native field soil; this greatly reduces the natural drying out process during the beginning of the plants field life. After transplanting in dry soil water in the plants.

Transplanting Broccoli Video

Some farmers will apply a furrowed in line of organic fertilizer along or around new transplants ,referred to as side dressing. This should be done only if the quality of the soil requires that boost.

Always water in a new start. This is the highest preventative measure you can take against shock

Bring the root zone of the crop to field capacity using drip irrigation.

Mulching

Mulching is an excellent alternative to weeding and it conserves water by requiring 1/10 of the regular use. Consider mulching your transplants with available organic materials (wood chips, grass clippings, clean straw, news paper) or compost. Organic mulching weed suppresses, conserves water and feeds important micro organisms in the soil. It does require large amounts of organic material and the initial application is time consuming.

Black plastic is a mulching alternative as well and is installed after the ground is prepared and before transplanting. Holes are punctured or burnt into the plastic and then transplants are planted. Black plastic mulch is used in larger farm operations and usually requires a partner irrigation system (usually drip). Black plastic mulch is a petroleum product and is not reusable after one season.

Documenting

Using the crop marker from the flat of seedlings add the transplant date (or transpose the information to a larger marker)and use as a end row/garden marker. Also record transplant dates in record log books.

Crop	Date and Amount Sown	Seed Co. & Seed Lot/Year	Comments on Germination & Seedling Growth	Prickout Date (if applicable)	Transplant Date (to Field)	1st and Last Harvest Dates	Yield Information	Other

Video on Record Keeping

Follow Up after Planting

- Set up irrigation system
- Return unused seedlings to propagation area. Refill the flats with starter mix and water thoroughly.
- Over the following week, monitor soil moisture in the root zone of transplants. Irrigate whenever the root zone reaches 50% of field capacity.
- Periodic, light overhead irrigation will raise the humidity around the seedlings, reduce the rate of evaporation and help minimize transplant shock.
- Observe transplant growth for changes in color, and damage due to predation.
- Replace lost seedlings with those stored from original planting.

Common Favorable Crops for Transplanting in the Mid-West

Cold Crops
Cabbages
Cauliflower
Brussel Sprouts
Broccoli
Onion

Warm Crops
Tomatoes
Peppers
Eggplant
Squash

Herbs
Basil
Rosemary
Thyme
Oregano
Parsley
Sage

Greens
Head Lettuce
Kales
Chards

Self-Evaluation Questions

1) List 3 environmental conditions favorable for successful transplanting of flat-grown seedlings?
2) What is the optimal range of soil moisture for transplanting seedlings?
3) Describe how the size, root nature, and vigor of transplants influence cultivation needs?
4) List 2 characteristics of seedlings at transplanting maturity?
5) List 2 necessary steps in preparing seedlings for transplanting?
6) What pieces of information are commonly documented in the propagation process?
7) What is the hardening off process?
8) List 2 characteristics of cell-tray grown seedlings at maturity?
9) List 2 necessary steps for preparing seedlings before transplanting them to the field or garden.
10) List the environmental conditions most favorable for successful bare root transplanting?
12) What should be considered when determining transplant spacing?
13) How deep should seedlings be transplanted?
14) What is the role of mulching in the transplanting process.
15) Describe the follow-up care for transplanted crops?

Resources

- *SARE*
- *New Organic Grower* by Elliot Coleman

IRRIGATION
on the farm

OBJECTIVES

Student will learn...

- optimal times to irrigate during different stages of plant development
- types of small farm/permaculture irrigation systems
- different sources of water for farm irrigation
- methods of water retention for permaculture

DEFINITIONS

- irrigation...a system of supplying water
- drip tape...perforated plastic tubing used to supply water to plants in droplets
- pressurized water...water that is under force
- water retention...the ability of a soil to hold water

When to irrigate...germination

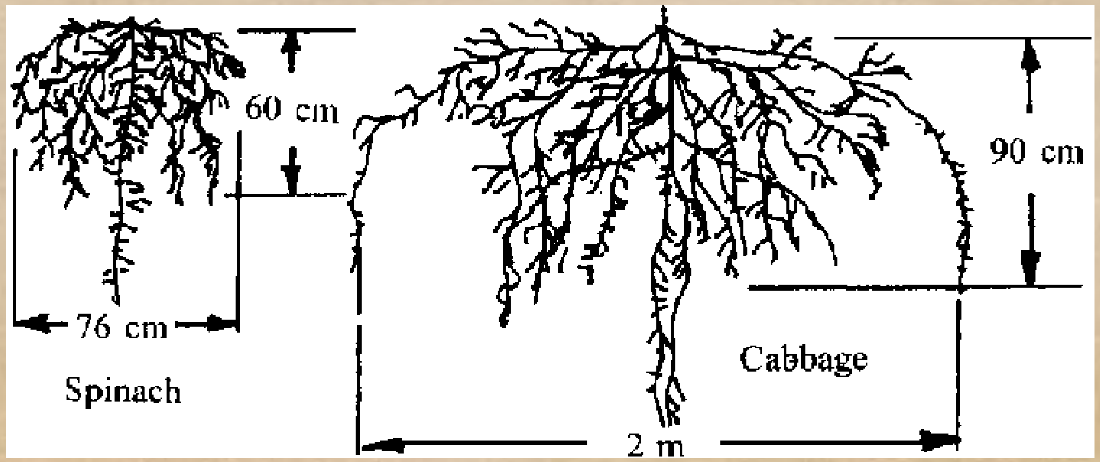
- Consistent watering is crucial at the time of germination in order to ensure there is water around newly planted seeds
- Water must be fine (mist) in order to not displace seeds

When to irrigate…young plants

- Crops take up more water as they grow bigger. For rapid growth, roots of young plants require consistent water.
- Too much water, however, will slow plant growth and lead to disease.

When to water...mature plants

- Mature plants require more water, but also have deeper roots for finding water
- Mature plants can store more water in stems and leaves, so watering does not need to be as consistent for survival.



When to irrigate...fruiting

- During fruiting, plants are using water to grow fruit.
- Many plants (tomatoes, watermelon) become less sweet if overwatered during fruiting.

Pressurized Irrigation

- Pressurized systems are either hooked up to local municipality water supplies that are pressurized or are attached to a well with a pump and pressurized tank.

Pressurized irrigation...overhead

- Overhead irrigation systems are designed to supply a large area with even coverage.

Pressurized irrigation...overhead

- Several manufacturers offer different types of heads for overhead watering

Pressurized irrigation...overhead

- Wobbler heads are simple construction heads. Interchangeable orifices allow for different sized droplets.
- Use small droplets for germination and large droplets for field growing

Low pressure irrigation...drip tape

- Drip tape is used at the base of plants

Low pressure irrigation...drip tape

- Drip tape advantages:
    - leaves of plants remain dry (especially important on tomatoes and other disease-prone plants
    - saves water and money

Low pressure irrigation...drip tape

Ways to lay drip tape:

- drip tape layer, under plastic mulch
- by hand

http://youtu.be/uMvi6fPDHbE.ext

Low pressure irrigation...drip tape

Many drip tapes have emitters---tiny holes---every 6 or 12 inches to let water escape

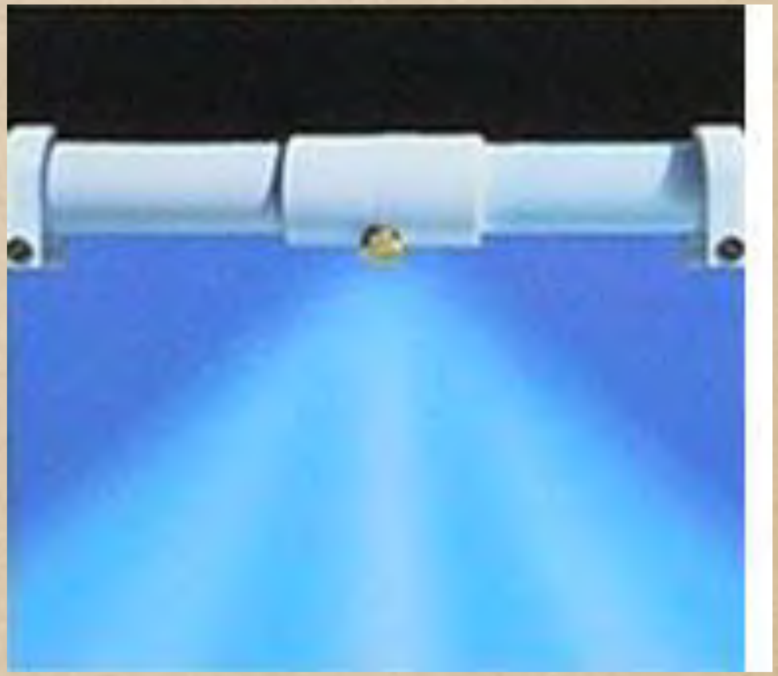
Low pressure irrigation...drip tape

Some drip tape systems use inserted emitters to water plants like bushes or fruit trees that are spaced far apart

http://youtu.be/4yLOWdMDELs

Greenhouse systems...misting

- Misting heads can be placed on "wands"
- Misting emitters can be suspended from overhead



Greenhouse systems…overhead

- To water in a greenhouse, use overhead emitters spaced every 24-36# for even coverage
- Greenhouses 20 ft and wider require two irrigation runs strung the full length of the greenhouse

Greenhouse systems...drip tape

Drip tape is also used in the greenhouse, with the same practices as in the field.

Greenhouse systems...

- Because light is diffused and there is no wind, water evaporates slowly from greenhouse soil.
- So less irrigation is required in the greenhouse.

Water sources…rainwater

- Rainwater can be collecting in barrels or large tanks.
- Raised tanks can feed drip tape systems using no electricity.

http://youtu.be/GUhox1ORIRk

Water sources...ponds and streams

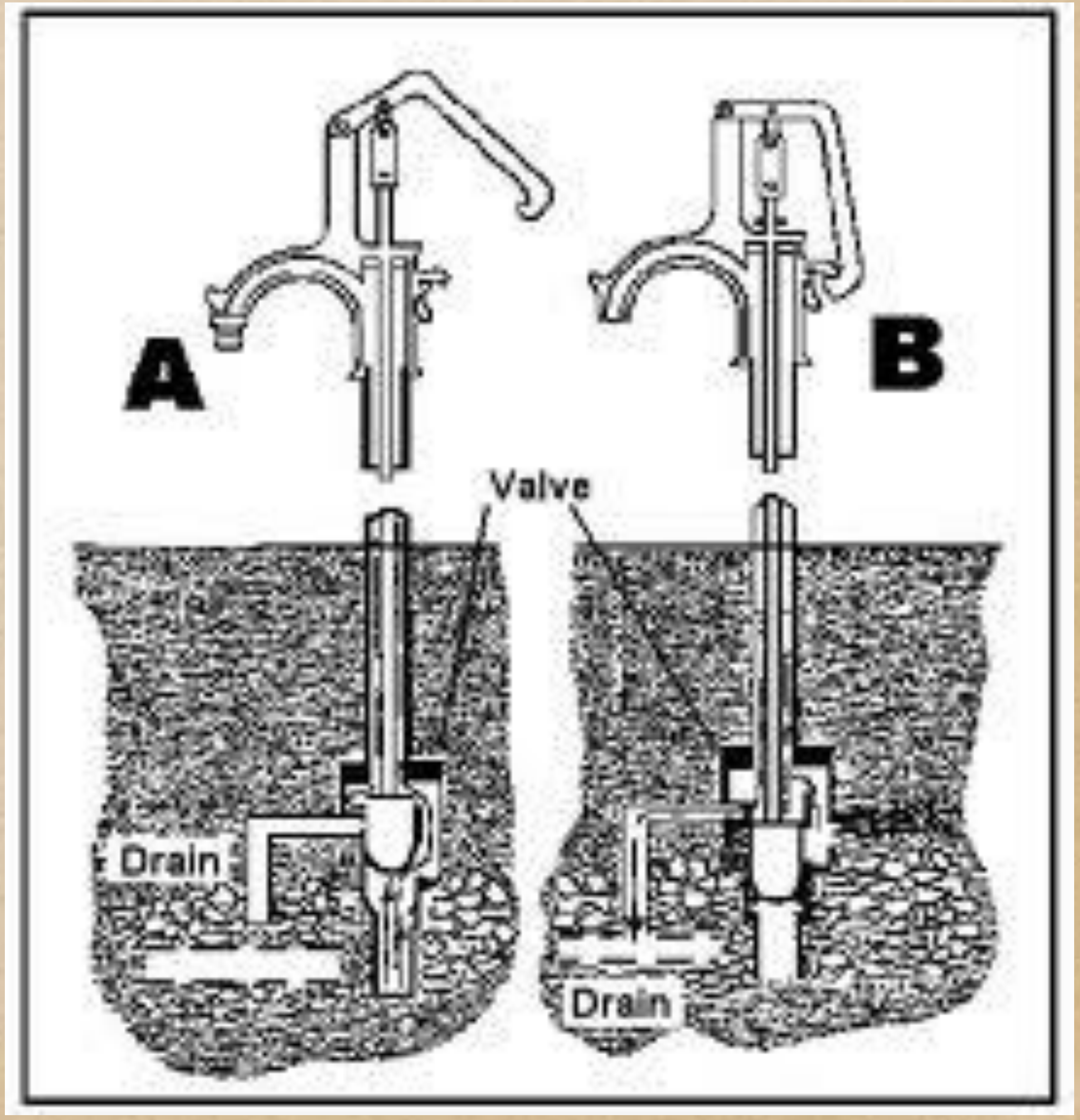
- Pumps can be used to irrigate with water from ponds and streams.
- In order to not plug up emitters, water must pass through a sand filter.

Water sources...groundwater

Groundwater can be stored in pressurized tanks. Underground water lines connect pressure tanks to water faucets.

Water sources...groundwater

Frost-free water hydrants prevent water from freezing in the hydrant.



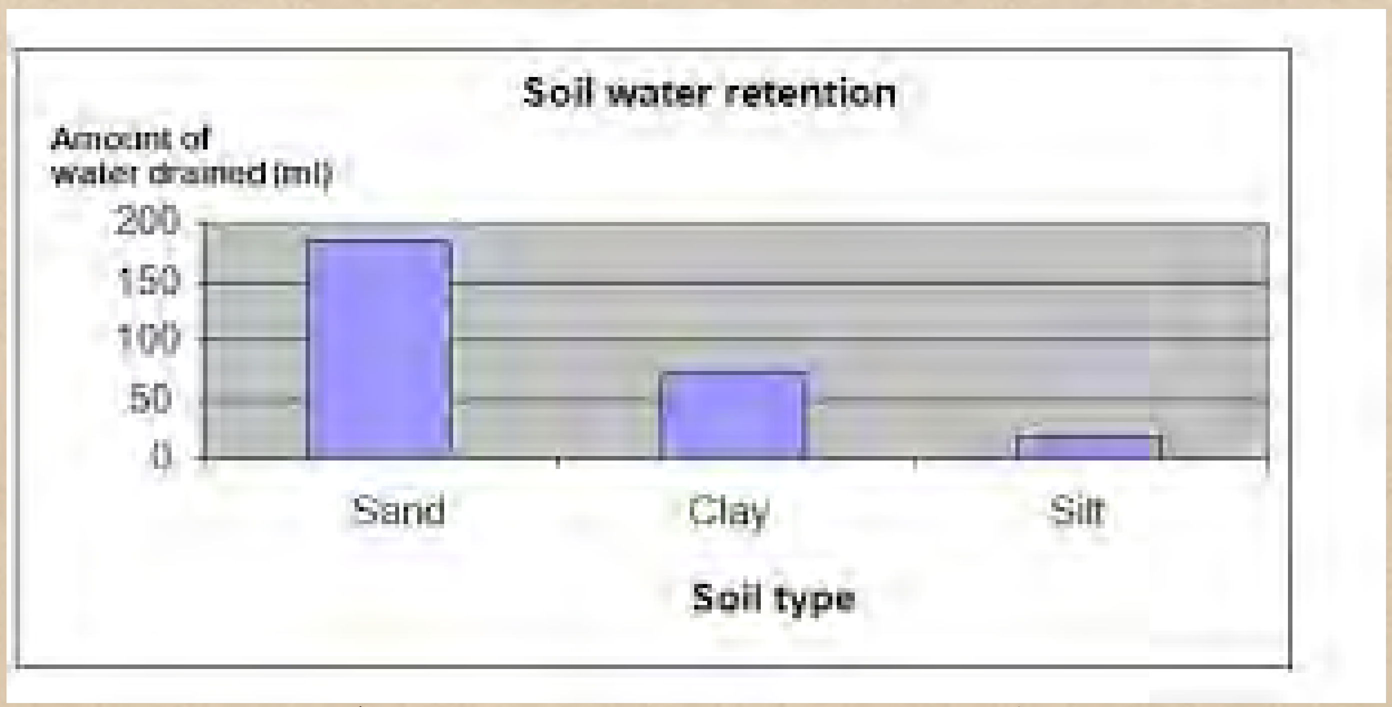
Testing water

- Testing water on an annual basis is recommended.
- Common problems include: high nitrate levels, chemical residue (creeks), poor PH balance

Retaining water

Irrigation systems for small-scale and permaculture farms need to include water retention strategies.

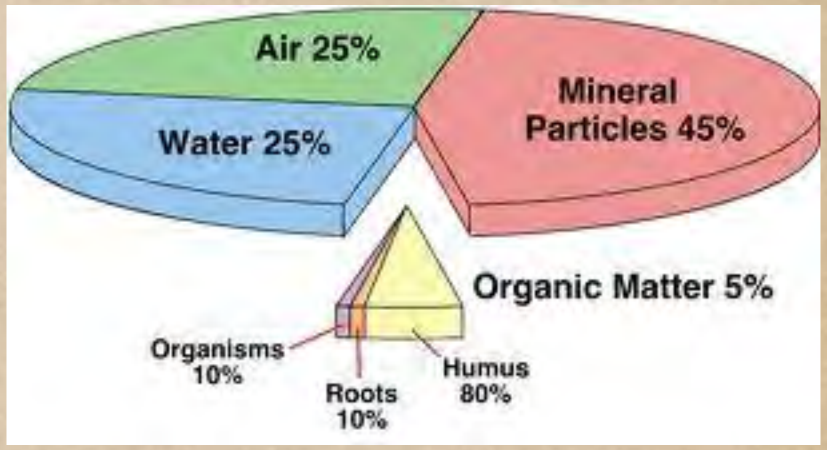
Retaining water...Soil water holding capacity



Check your soil survey to gather information about water movement and retention on your property. Note tables that describe how fast water moves through your soil

Retaining water...improving soil

- Soils with high organic matter will retain more water
- Adding compost and growing cover crops are great ways to build organic matter



Retaining water...mulching

- Organic mulches help hold water in the soil
- Apply mulch around young plants

Retaining water...mulching

Sources of mulch include:

- straw
- grass clippings
- leaves

Retaining water...shade

- Shading crops and soil is another way to minimize evaporative loss
- Permaculture designs place shade-tolerant plants under trees with leaf canopy
- Shade cloth can be suspended on greenhouses

Self-Check Review Questions

- What are the optimal times and ways to irrigate during different stages of plant development?
- What are the major sources of water for farm irrigation?
- What are some methods for water retention?

Resources

- dripworks.com
- www.irrigation.org
- ga.water.usgs.gov/edu/wuir.html
- wqic.nal.usda.gov/irrigation-1


Managed
Grazing

Learning Objectives

The learner will…

- Understand the history of grazing
- Learn how to manage a pasture using the 4 R’s
- Learn forage and harmful weed varieties
- Learn to set up an electric line fence

Grazing Terminology

Foraging is searching for and exploiting food resources. It affects an animal's fitness because it plays an important role in an animal's ability to survive and reproduce.

Frequency of Grazing: How many times a plant is grazed in a growing season (one time is optimal).

Intensity of Grazing: How long an animal grazes in a specific location.

- **<u>Organic</u>**: Grown or raised without the use of antibiotics, pesticides, herbicides, or other synthetic chemicals and using organic matter building protocols.

- **<u>Overgrazing</u>** occurs when plants are exposed to intensive grazing for extended periods of time, or without sufficient recovery periods.

- **<u>Pasture Raised</u>:** General term for any animal that rarely sees confinement.

Happy Cows http://youtu.be/O6-Y-E5UD0o

Overgrazed, dry Pasture

Unhappy horse!

Rotational Grazing Division of pastures into units for grazing in sequence throughout the grazing period. Utilizing rotational grazing can improve livestock distribution while incorporating rest period for new forage

Sustainability leaving resources, including the land, in a productive state going into the future. Meeting the needs of the present without compromising future generations needs.

Warm season - A plant that exhibits optimum growth during summer months.

Winter annual - A plant that establishes from seed, grows, sets seed and dies in one growing season beginning with germination in the fall and dying in the spring/summer.

History of Grazing

- The history of grazing started with man's evolution. The animals roamed and grazed on the land free. Man hunted and ate the animals to stay alive.
- Humans domesticated animals by gathering them into herds using dogs in a tribal or nomadic way.
- Penning them up in corrals and pastures allowed easy use for milk and meat.

Border collie herding

Massai in Africa
Tribal/Nomadic

Broadleaf

Grass: High & Tough

Legume example
Clover: Low & Soft

Forage Plants

The purpose of establishing forages is to establish adapted and compatible species and varieties of cool season grasses and legumes to:

- Improve or maintain forage protein content,
- Improve or maintain digestibility and palatability
- Eliminate need for nitrogen fertilizer
- Provide better seasonal distribution of forage
- Improve animal performance

The goal is also to supplement livestock operation during periods when lean forages are either dormant or have decreased growth because of unfavorable weather conditions.

Pasture Plants
Broadleaf
Grass
Legumes

Types of Grazing

- Open Pastures

- Rotational/Strip
- Managed Intensive Rotational Grazing (MIRG)

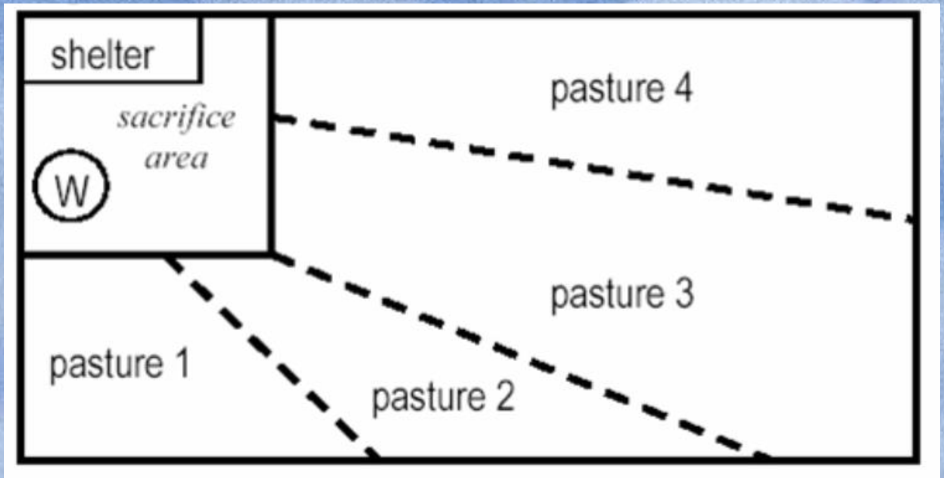
Open Pasture

- Animals are left in one location.
- Uneven grazing is common due to concentration of livestock around watering and feeding areas.
- Strong fences surround the area with no need for movable electrical fencing.

Rotational Grazing

- Pasture land is split into multiple paddocks to allow for rest and rotation. The sacrifice area provides shelter from the weather & insects; and can provide outdoor access when time on pasture should be limited.

- Permanent fencing separates paddocks



Graphic courtesy of the University of New Hampshire Cooperative Extension

Managed Intensive Rotational Grazing

- Strip grazing places animals on a strip of land that is sectioned off by temporary electric fencing. The size of the strip that is allocated to livestock depends on available forage and on the size of your herd.

- The size of the strips your animals are grazing is always subject to change throughout the grazing season.

MANAGED INTENSIVE ROTATIONAL GRAZING (MIRG)

- MIRG is commonly known by several names, including Intensive Cell grazing, Mob Grazing, or High-Density Grazing.
- The herds graze one portion of pasture while allowing the others to recover. Resting grazed lands allows the vegetation to renew energy reserves and deepen root systems, with the result being long-term maximum biomass production.
- An optimal pasture should contain several types of forage plants that are nutritious for cattle. MIRG is a grazing practice that is quickly gaining popularity in the grass-fed, naturally-raised livestock sector of raising livestock, primarily with cattle, but also with sheep, goats, poultry, and even horses.
- Farm Layout for Prescribed Grazing ttp://www.youtube.com/watch?v=En-SaFxubFk This video is from South Carolina, but the principles are the same for Midwest farms.

Shelters

Repurposed older barn

Temporary Shelter

An older barn can be an asset or a liability depending on its condition. Old farm buildings of the countryside contribute to the landscape & history of the farmstead; they can show the agricultural methods, building materials, and skills that were used. However, they may require restoration to be safe and useable.

Grazing animals, overall, have less need for shelter than has been assumed in the past. As long as forage, water, and mineral is available, shelters can be temporary and cheap if need be.

Pole barns are more typical of modern building styles. They are usually cheaper to build and maintain than older barns. But, they are unlikely to last as long as the strongly built barns of yesterday!

Pasture Management

- Weeds/Managing Poisonous Pasture Plants
- The 4 R's of Grazing Management
- Livestock Watering
- Electrical Fence/Equipment
- Shelters
- Pasture Managing Tips

Weeds

- Weed control is very important in pastures and hayfields. A weed is a plant growing in an area you do not want it to grow. Keep in mind that just because a plant isn't grass, doesn't mean it's a weed. If it provides good nutrition it can be an important part of the forage mix.
- A key step in managing weeds in any pasture system is identification. Once the undesired species in a pasture system are identified an integrated approach of management can be implemented to control weed populations.

Wild Mustard

Buttercup

Burdock

- **Weeds in pastures and hayfields** can reduce forage yield and quality.

Weeds also have the potential to cause injury or death to livestock in the form of a toxic plant. Besides reducing yield and quality, weeds can interfere with hay drying. Weeds compete with your desired forage and can cause a weakened stand of your grass. There are two types of weeds: *Cool season* and *Warm season*

  - Cool Season Weeds - the best time to control is October through December. It is also possible to control cool season weeds February through April.
  - Warm Season Weeds - the best time to control is April to mid July for most species.

- **The first step in weed control** is identifying the weed or weeds you are trying to get rid of. You should scout your pastures looking for weeds and identify them. Keep a record of what weeds you have in each field and when you start seeing them. This will help determine if your control program is working. Some weeds may take a few years to get under control.

- **Prevention** is any activity that keeps weeds from getting into your pasture. Many weeds are spread by seed. These seeds are dispersed by hay bales, livestock movements, mowing equipment, wind, water, and wildlife. Weeds can be introduced by planting contaminated forage seed. Certified seed is worth extra cost.

- Management practices that maintain proper soil pH and fertility will ensure forage stands with less weed competition. The four control methods below should be used in combination to fight weeds. The effectiveness of control depends on timing.

1. **Grazing management** is one way to control weeds in a pasture situation. This control allows desired plants to become strong and out compete the weeds. Rotational grazing helps to control weeds by giving desired plants the opportunity to rest and grow undisturbed before being grazed again.

2. **Mechanical control** usually involves mowing to control weeds. Mowing is usually more effective on broadleaf weeds than grass weeds. Mowing does have negatives such as cost of fuel, may not help with large weeds, and can spread seeds around encouraging more weed growth.

3. **Biological control** involves the use of biotic agents such as plants, herbivores, insects, and nematodes to suppress weeds. Biological control is a relatively new area, but progress is being made. Control is usually not complete and may take several years.

4. **Chemical control** is limited in organic practices. Some less toxic chemical options may be acceptable for serious infestations.

Poisonous Plants

Most common toxic plants in Indiana:

- Alsike clover
- Bitter nightshade
- Black nightshade
- Common cocklebur
- Dutchman's breeches
- Dwarf larkspur
- Groundsel
- Johnson grass
- Poison-hemlock
- Redroot pigweed
- Field horse nettle
- Spotted water hemlock
- Sweet clover
- White snakeroot
- Wild black cherry
- Yew

Use this link to see pictures and additional information about these toxic weeds.
http://www.ansci.cornell.edu/plants/php/plants.php

The 4 R's of Grazing Management

Overgrazing

- Sustainable grassland production is based on **R**emoving seed heads, **R**ight starting height, **R**esidual leaf area, and **R**est period.
- Grazing management is the foundation of grassland-based livestock production since it affects both animal and plant health and productivity.
- Overgrazing can occur under continuous or rotational grazing. It can be caused by having too many animals on the farm or by not properly controlling their grazing activity.
- Overgrazing reduces plant leaf areas, which reduces interception of sunlight and plant growth. Plants become weakened and have reduced root length, and the pasture sod weakens. The reduced root length makes the plants more susceptible to death during dry weather. The weakened sod allows weed seeds to germinate and grow. If the weeds are unpalatable or poisonous, major problems can result.

4 R’s: Right Starting Height

Generally, pasture vegetation should be grazed at a height of 6 to 8 inches down to a residue height of 2 to 3 inches. Animals should then be removed to allow the pasture to rest and re-grow to the recommended 6 to 8 inch height. These grazing heights provide optimum nutritional value and palatability for the animals along with growing conditions for the vegetation to remain healthy and vigorous.

4 R's: Removing Seed Heads

Alternative to Haying: Pasture stomped down by livestock.

Haying

- Removing plants from the field to store for future feeding.
- May compromise the nutrient or organic matter value of the pasture
- Provides stored forage during times of flood or drought, or during the winter when grazing is not feasible.
- Use some pastures for hay production if your animals cannot keep on top of the rapid growth of grasses or if you don't have enough animals to keep ahead of spring growth forage quality.

4 R's: Rest/Recovery periods for Pasture.

- At least 30 days must be allocated for all pastures and paddocks that have been grazed so that grass has a time to recover and come back ready for the next grazing session.

- More time of rest is needed for times when pastures are experiencing slower growth than during the time of year when growth is very fast.

- It is apparent that appropriate land use and grazing management techniques are needed to balance maintaining forage and livestock production, while still maintaining biodiversity and ecosystem services. Through the utilization of grazing systems and making sure to allow proper recovery periods for regrowth, both the livestock and ecosystem will benefit. Along with recovery periods, producers can keep a low density on a pasture, so as not to overgraze. Controlled burning of the land can be valuable in the regrowth of indigenous plants, and new lush growth. Additionally, producers can increase plant and species richness through grazing, by providing an adequate habitat. Although grazing can be problematic for the ecosystem at times, well-managed grazing techniques can reverse damage and improve the land.

<u>How your cattle or sheep graze is influenced by a number of things</u>:

- Types of vegetation; topography; location of water, salt, and minerals; shade; prevailing wind directions; and routine grazing habits.
- On average, during a 24 hour summer day, a range cow spends six to ten hours grazing. She will spend a little more than twelve hours resting and ruminating. During the rest of her 24 hour day, the cow will travel, drink water, lick salt and minerals, and rub and nurse her calf.
- Animals eat the lowest growing (soft) and most nutritious plants and leave the tall (tough) plants. Spot grazing occurs when animals repeatedly graze the same areas; this causes uneven growth in a pasture and growth of weeds.

Cows generally have two main grazing periods. One is from sunrise to midmorning. The second is from late afternoon until sunset.

<u>Rotate animals on a regular basis</u>.

- Most livestock species like routines, so if you are going to be changing paddocks on a regular basis, try to stick to a particular time to change them. If it's possible, try to move them once every 24 hours.
- You do have the option, depending on paddock size, on the size of the herd and growing conditions, to rotate animals much sooner, as in once every two to four hours at a time. This is not an option if you have an off-farm job where you cannot be around all day to change paddocks every few hours.
- You also have the option to set your animals to graze a paddock for several days at a time, depending on the time you have or cannot have to change pastures.

4 R's: Residual Leaf Area

Seeding Pasture and Grasses
http://www.youtube.com/watch?v=6ksghZPj-zg

Dead grass and bare patches in pastures are at risk for erosion and an open invitation for weeds and undesirable grasses to take over. To ensure pastures are dense and nutritious, bare patches should be
seeded in the late winter/early spring or late summer.

The basic steps of seeding bare patches are

- **controlling existing weeds,**
- **preparing the seedbed,**
- **seeding the right seed at the right time, recommended for Indiana is this kind of seed ideal planning time is:**
- **maintaining a moist environment for seed germination.**

Livestock Watering & Salt

Watering Trough is positioned under wire so that animals can drink from either side.

View video on meeting animals water needs in pasture: http://www.youtube.com/watch?v=NLO1teG0Dxs

Salt is left out for animals to eat free choice. This is an important part of an animal's nutritional needs.

Setting Up & Moving Fences

Before attempting to set up or move an electrical fence, turn off electricity.

Off… **On…**

Then string the electrical wire from one end of the pasture to the other using posts designed for electrical use. Make sure nothing is touching the ground or anything that is not a conductor of electricity.

ELECTRICAL EQUIPMENT

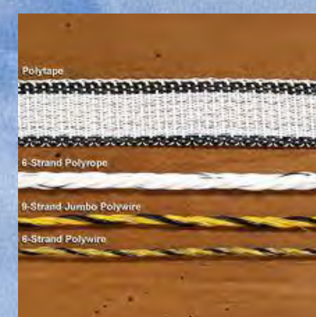
Ratchet Tensioned

Wire Spools

Posts with Insulating Rubber

Temporary Stakes

Electric Fence Line Testers



Tape and Wire

Loss of Electricity

- Check the Line with a **voltage tester.**
- Even when the electricity is turned on there is a two (2) second delay before one feels the jolt of electricity (which is why you may not immediately feel it).
- If the electrical line touches anything **it will ground out** unless what it is touching is covered with rubber.

<u>Two Kinds of Currents</u>

- Direct Current - on at all times
- Alternating Current - on and off every two seconds.

Electrical Connections: Do's & Don'ts

- Insulate your LIVE wire with rubber or other type of insulator where it touches something other than itself. Otherwise, it will ground out and not work.
- A NON-LIVE wire is not insulated where it touches something other than itself. You can touch that wire without being shocked by the electricity.

Correct (live)   Incorrect (non-live)

Pasture Management Tips

Pasture Management Video http://onpasture.com/2013/06/24/grazing-management-basics/

- To promote uniform and vigorous growth, clip or mow pastures periodically (two or three times each season). This helps to stimulate new growth in areas that have grown tall and gone to seed.
- Scatter and disperse manure clumps by dragging pastures with a chain-link or flexible tine drag. This reduces areas of rejected forage and helps to control parasites.
- Lime and fertilize pastures according to soil test results. Maintaining an optimum soil pH through liming is important for desirable cool-season grasses and legumes.
- Maintaining adequate nutrients in the soil is also important. Excess nutrients can cause animal health as well as water quality problems, so supplement with fertilizer only when a soil test indicates a need. Your animals will provide free fertilizer!

Using animals manure puts nutrients back into the ground which in turn makes the pastures grow even faster.

Spotlight on Permaculture

- Using native grasses & legumes may provide forage during drought periods
  - Prairie plants have very deep roots which can reach into soil moisture deep below surface
  - Emergency harvest of CRP (Conservation Reserve Program) prairie fields during droughts
  - Improving Forage Production & Quality with Native Legumes http://www.youtube.com/watch?v=FBVmOqboZmg

Self-Review Questions

- Why is it necessary to rotate animals in managed grazing systems?
- What are the 4Rs?
- What should be done to prevent and control poisonous weeds?
- What are shelter options?

References

- *Getting Started with Beef & Dairy Cattle* - Heather Smith Thomas
- Managed Intensive Rotational Grazing (MIRG) – Wikipedia
- Open Pastures (Spring 2013-Issue 35), Official publication of the American Grass-fed Association
- Pastures, Fencing and Watering on Small Acreages – University of Rhode Island
- Poisonous Plants of Indiana – Cornell University http://www.ansci.cornell.edu/plants/index.html
- Weed Identification in Pastures and Hayfields -North Carolina State University Weed Science and Virginia Tech Weed Science (photos and definitions)
- *You Can Farm* - Joel Salatin

Weed Management

Getting the most out of unwanted plants

Objectives

- Assist identification of common weeds
- Provide detailed methods for eradication, prevention and usage of weeds
- Provide info on the history of weeds and their role in farm ecology

What is a weed?

Basic definition - any unwanted volunteer plant that reduces the production of a crop.

Long and Short of it: Increasingly difficult to answer and depends on who you talk to.

Another Definition

A weed is any plant, native or non-native, that interferes with crop production by doing more harm than good and has a habit of encroaching where it is not wanted.

What is a weed?

Complex Definition - "weeds" vs Weeds. most weeds are what ecologists call early successional plants or pioneers. they are tasked with covering the soil and taking up soluble nutrients. This prevents soil degradation and adds carbon and shade, allowing mobile biology to exist. Early succession sets the stage for more complex systems (forests, grasslands, wetlands) to evolve and stabilize.

"weeds" - abundant, underutilized plants with some beneficial characteristics

Weeds - abundant, invasive plants with no apparent benefits and some unwanted characteristics (poisons, heavy nutrient feeding, dense foliage/roots)

A few terms

Native - Plants that are part of the wild, undisturbed food web and have functional roles in an ecosystem. May be abundant or scarce.

Invasive - abundant plants with high reproductive success apparently regardless of conditions. May be native, or exotic.

Exotic - immigrant plants from other parts of the world that may be grown in season or become naturalized or invasive.

Naturalized - immigrant plants that are not necessarily invasive and may perform an ecological function in place of a native plant

A few terms

Seed Bank - Not all seeds germinate after being scattered. They remain viable in the soil for long periods of time under the right conditions.

Weed Management - a mix of eradication, prevention and usage. Making weeds work for us as much as possible.

Eradication - complete elimination of growing weeds and their seed bank.

Prevention - stopping germination of the seedbank

Usage - Harvesting plants for a purpose and and allowing them to reproduce or remain viable. Providing food or shelter.

Negative effects of weed colonization

Competition - Weeds occupy valuable space and compete aggressively for light, air, nutrients and water. Weeds close to crops will reduce crop quality and viability. These effects are functions of proximity to the crop, and the density of colonization.

Allergen production

Increased Habitat - Vegetation provides a place for pests to lie in wait.

Interference - Weeds can make cultivation and harvest a more difficult task when using machinery

Positive Effects of Weed Colonization

Soil cover - Foliage shades the soil and builds organic matter over time, preventing evaporation and erosion. Roots penetrating the soil can break up compacted areas and allow water to penetrate more easily.

Nutrient holding - bare soil is subject to leaching of soluble nutrients, weeds take these up rapidly and then release them back to the soil at the end of season.

Indicators of soil quality - All common weeds have preffered soil conditions which trigger their germination. Some prefer poor soil, other very rich or overfertilized

Nutrient Cycling - the nutrients held can be taken in by foraging animals and transported.

Increased Habitat - with foliage cover comes a better habitat for soil biology like insects and fungi. More diverse soil life can hold more nutrients and water and can produce cold CO2 for direct uptake by plants again.

Common Midwestern Agricultural Weeds

Mugwort

Hemlock

Ragweed

Common Dock

Weeds

Mugwort

-Aggressive, quickly spreading,

- Exotic

-Flavoring herb, insect repellent,

-Toxic in high doses

Weeds

Hemlock

-Aggressive, but easy to eradicate if prevented from seeding

- Poisonous to ingest, some may be allergic to the touch

- Exotic

Weeds

Ragweed

- aggressive, easy to pull, producing many seeds
- Cultivated by native americans as an oilseed before introduction of corn.
- Native

Weeds

Common Dock

- Large taproot and prolific seed makes eradication difficult.

-May be prevented by chopping during flowering.

-Native

Common Agricultural "weeds"

thistle

dandelion

chickweed

purslane

wild geranium

Stinging nettle

wild chamomile

Lambs Quarters

"weeds"

Thistle -

edible roots

insectary plant

seeds attract birds

"weeds"

Dandelion -

soil builder

edible leaves, flowers and roots

insect plant

Aids in ripening of fruits

"weeds"

Chickweed -

High protein. Edible for humans. Chickens love it.

Shade loving

"weeds"

Stinging Nettle -

Used for nutrient and herbal tea.

Contains Histamine, a compound that creates the stinging feeling

"weeds"

Wild Geranium -

Contains pyrethrin, a popular insecticide

"weeds"

Purslane -

Once a weed, now a valuable salad green

"weeds"

Wild Chamomile

- Used to make nutrient and herbal tea.

Lambs Quarter’s

Lamb’s Quarters

- Edible for livestock and humans; leaves, shoots, and seeds

Methods of weed management

- Eradication
- Prevention
- Usage

Eradication

- Cutting hoeing,sickling

https://www.youtube.com/watch?v=VYRH5Gn2Wbg

- Pulling - By hand or with machinery(see tillage ppt) http://youtu.be/5Ojl28uJeUo
- Spraying herbicide.
- Flaming http://youtu.be/vDpeHp_98zQ
- Seedbank Depletion

Prevention

Seedbank depletion is the #1 way to prevent weed pressure.

By staying on top of weed production and preventing reproduction, we are able to gradually reduce the rate of weed colonization in our soil.

Mulching - A heavy layer of raw, undecomposed organic material will prevent light from penetrating the soil and alerting seeds to germinate. With successive years of mulching, layers of decomposed organic matter are built up, burying weed seeds.

https://www.youtube.com/watch?v=wffoeYUFK7k

Seed Bank Depletion

Cover cropping - once staple crops have been harvested, planting of second, less productive but hardier crop follows.

https://www.youtube.com/watch?v=jl7wncXBY0w

Polyculture - a system where multiple crops are planted in a space. They are chosen because they are mutually tolerant or beneficial. Plant density is increased and soil is covered so weed germination is decreased.

Seed Bank Depletion

Careful composting - Getting compost piles above 140 degrees Fahrenheit will decompose weed seeds.

Tool cleaning - Soil is the biggest importer of weed seed. Remove it between using tools in different areas.

Daily inspection - By far the most important action against weed pressure.

Usage

The majority of plants have some uses:

Biodynamic preparations - Nutrient teas and insect repellent sprays for crops can be made with various weed.

Compost - Adding weeds to compost both inoculates it with soil biology and adds to the nutrient content.

Animal shelter and forage - Most plants can be eaten by something or at least provide shade

Soil cover - Aggressive grasses can be cut frequently to provide mulch. Fallow or unplanted fields should have something growing on them in order to hold nutrients

Food- Many weeds are edible.

Moving Forward with Permaculture

One of the main principles of Permaculture is that we should use and value diversity and biological resources. Weeds can be an important resources if we learn about them and how to use them. Learning about common plants allows new connections to be made on the farm. We must obtain a yield without damaging our land, and proper weed management is a big part of both.

Self Review

- What is a weed?
- How are weeds dispersed?
- What are some benefits of weeds in a cropping system?
- What are some of the characteristics of weeds that allow them to compete so well in cropping systems?
- Why control weeds?

Resources

- *NRCS Local Extension Office*
- *Good Weed, Bad Weed* by Nancy Gift
- article “Weed the Soil Not the Crop” by Anne & Eric Nordell
- “You Can Farm” by Joel Salatin
- “Gardening When it Counts” by Steve Solomon

PLANT PATHOGENS

Disease Management

Learning Objectives

- Become familiar with various types of plant pathogens or disease agents.
- Examine various methods of disease management.
- Familiarize student with common diseases for crop families in the midwest region

Plant Pathogen Overview

- A plant pathogen is any harmful infectious agent, organism, or condition that reduces a plant's overall vitality, inhibits its growth, or limits the ability of the plant to survive and reproduce.
- Pathogens can be delivered in a multitude of different ways. These include: bacteria, fungi, viruses, nematodes, oomycetes, and abiotic toxicities.
- There are several different factors that need to be present in order to create an outbreak of disease on the farm. The pathogen must be present. There must be suitable host plants around. And there must be favorable environmental conditions for the growth and development of that particular plant pathogen.

Plant Disease Agents

- *Bacteria*
- *Fungi*
- *Viruses*
- *Nematodes*
- *Abiotic*
- *Oomycetes*

Plant Disease Agents

- *Bacteria*: These single cell organisms absorb the nutrition from their host plant and thrive by killing the plant and living off of their decomposing organic matter. This is often described as a saprophytic relationship. Bacterial pa
cause blights, rots, and wilts.

Onion rot caused by bacteria can be avoided by spacing bulbs closer. See http://extension.umass.edu/vegetable/articles/stop-rot-using-cultural-practices-reduce-bacterial-bulb-decay-onions

Plant Disease Agents

- *Fungi*: Fungal pathogens are spread by many different environmental conditions such as wind, water, seeds, human and other non-human vectors. (A vector is a host capable of transferring a particular pathogen.) Fungi that are capable of regenerating spores during the growing season and re-infecting plants are known as polycyclic. Fungi that must wait for next

Apple Scab is caused by a Fungus and can be treated with organic fungicides https://www.extension.purdue.edu/extmedia/BP/BP-1-W.pdf

Plant Disease Agents

- *Viruses*: Viruses are pieces of genetic material (RNA/DNA) that disturb the plants by mimicking naturally occurring genetic abnormalities. There are more than 700 plant viruses known. Viruses can be spread by tractors or equipment, tainted seed, or by a traveling vector.

Potato Virus Y is caused by a virus which is transmitted by aphids. For more information see http://labs.russell.wisc.edu/vegento/crops-and-insects/plant-pathogens/

Plant Disease Agents

- *Nematodes*: Nematodes are both a pathogen and a vector. Nematodes are microscopic worms and are one of the most abundant phyla with over 20,000 different species. A nematode either infects a plant by injecting a needle like mouth into the plant or it actually enters the plant with its entire body. The nematodes' saliva is the infecting agent and disturbs the metabolic process of the plant causing diseas

Carrots that have been diseased by nematodes. See http://cetehama.ucanr.edu/?impact=718&a=7816

Plant Disease Agents

- *Abiotic*: This refers to deficiencies in the soil or surrounding environment that cause a debilitating illness that is harmful or fatal t

Iron deficiency in the soil.

Magnesium deficiency in soil.

http://msucares.com/crops/comhort/tomatodisease/

Plant Disease Agents

- *Oomycetes*: These organisms act much like a fungi, however they have a very different evolutionary history. They have mobile spores and can be primarily spread by both wind and water. They can also be spread by vectors. An example of an oomycetes is "downy mildew" also known as "damping off."

Oomycetes are responsible for this late blight. This is the same organism responsible for the Potato Famine and still has severe economic repercussions when it occurs today.

Common Diseases in the Midwest See the videos detailing each

- blossom end rot http://youtu.be/6uObcfRWdK0
- early and late blight http://youtu.be/nqGODg8jhsI
  http://youtu.be/9PabiuQ7wVI
- powdery mildew http://youtu.be/9ZuTUiRD3Cs
- downey mildew http://youtu.be/sz0vZ-t0gyg
- Scab http://youtu.be/tj8JCh4Why4
- peach curl http://youtu.be/9Wzu-aBVKdw

Disease Management

- Plants often have developed natural defenses against pathogens. Some plants have developed disease tolerance. Some plants have developed disease resistance. Plants that are disease resistant will exhibit characteristics that actually repel certain harmful disease known to attack that particular plant. Plants that are disease tolerant can live with a problem pathogen but survive without any substantial reduction in yield or overall health.

Disease Management Strategies

- Proper greenhouse management can be extremely helpful in the control of outbreak and spread of pathogens. Disinfecting all soil trays and propagating mediums greatly reduces the incidence of pathogens.

- See http://youtu.be/FzQyucZwj-E

Disease Management Strategies

- A solid approach to crop rotation will also limit the spread and overall effect of certain diseases. This is a result of diversity increasing overall vitality, limiting host species, and reducing environmental conditions needed for disease to flourish and spread in similar varieties or families of plants.

Disease Management Strategies

- Recognizing pre-existing factors that may contribute to pathogen outbreak is an important aspect of disease control. An example would be being vigilant and wary of downy mildew in a very wet or coastal environment.

Identifying the problem with the plant is the first step. See http://msue.anr.msu.edu/news/signs_and_symptoms_of_plant_disease_is_it_fungal_viral_or_bacterial for information on distinguishing between viral, bacterial, and fungal diseases.

Disease Management Strategies

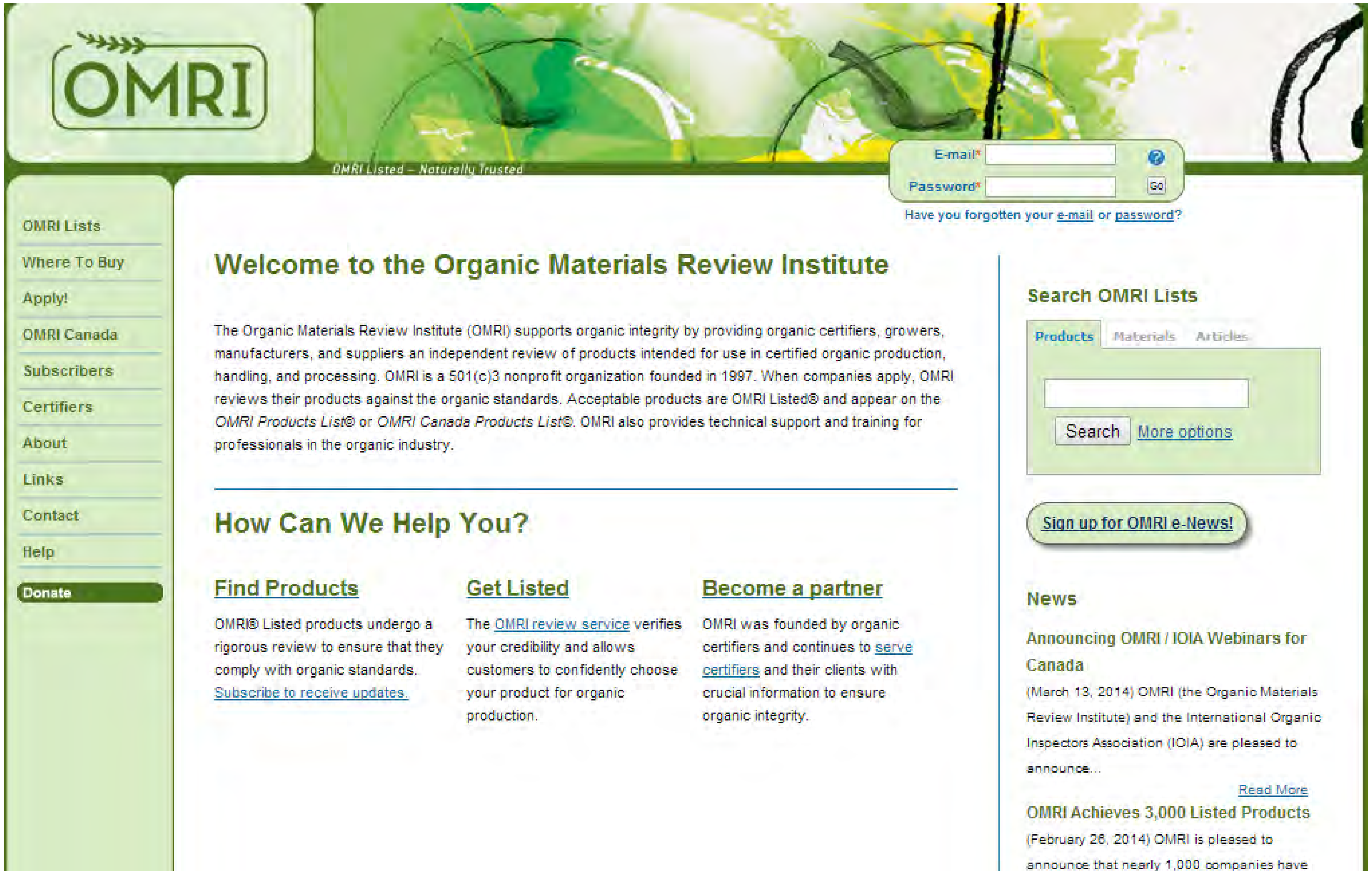
- In some organic situations, chemical control of disease is necessary and allowed by organic standards. Affected host plants can be physically removed or treated with such elements as copper, sulfur, or neem. It is always recommended that you consult with an expert before using or adding any amendment to your fields to help control disease.

Disease Management Strategies

- Overall plant vitality is probably the single most important element for fighting and combating disease in your garden or field. Pathogens have the tendency to attack weak or stressed plants in the garden. If a disease establishes itself using the weaker plants it can often jump to the stronger crops. Therefore, maintaining conditions favorable to general plant vitality can significantly reduce the occurrence of disease. Removing harvested plants quickly and composting effectively will reduce instance of pathogens as well.

OMRI
Organic Materials Review Institute

Use OMRI’s website to find appropriate products for disease management.



Assessment/Review

- What is a vector?
- What are several types of pathogens and how do they affect the plant?
- What essential disease prevention methods should be used on the farm to reduce the risk of pathogens?

Resources

- https://ag.purdue.edu/btny/Pages/default.aspx
- http://msucares.com/insects/index.html
- http://msue.anr.msu.edu/news/signs_and_symptoms_of_plant_disease_is_it_fungal_viral_or_bacterial

Insect Management

Common insect pests, beneficial insects, and management strategies

Learning Objectives

- Gain a basic understanding of the balance of insects on the farm/garden (pests and beneficial insects.)
- Be able to identify a number of common pests and suggest methods of control.
- Be able to identify several beneficial insects and discuss how they interact with crops and insect pests.

Insect Controls on Farm

- Remay- Fabric covers used over crop beds and rows to keep out insects.
- Beneficial/Preditory insects- insects that help control pest insect numbers by eating or otherwise killing species that are harmful to crop production. See also http://youtu.be/_8R4G4JIQhA
- Companion Plants- Plantings within a crop row or in a nearby pollinator strip to benefit a crop by attracting and housing beneficial insects for that crop.
- Bird Houses- Attracting and housing birds that can eat harmful insects is another organic method of pest control.

Insect Controls Used on farm

- Hedgerows and Pollinator Strips- Rows of trees, shrubs, and other plants around the perimeter of farms or between crops that create isolated environments protected from external problems and can also attract birds and beneficial insects to control pests.

- OMRI Approved Insecticides- OMRI, The Organic Materials Review Institute, supports organic integrity by providing organic certifiers, growers, manufacturers, and suppliers an independent review of products intended for use in certified organic production, handling, and processing. www.Omri.org.

Monitoring Insects

- The most important step in pest control is monitoring.
  - Keep an eye on plants for any signs of insect damage.
  - Keep an eye on insect populations, both pests and beneficials.
- Small populations of pests can be naturally kept under control, especially if companion plantings have attracted enough beneficial insects.
- This video details a few ways to monitor insects http://youtu.be/AS3gsSCEwbo

Safety When Spraying

When a “save-the-crop” approach must be taken and sprays or dustings will be used, check that organic products meet OMRI standards.

Always follow the safety protocol on the product you use.

See this video for tips on spraying.

http://youtu.be/B8WxFRe70qI

Common Harmful Pests

- Corn Earworm
- Squash Bugs
- Striped/Spotted Cucumber Beetle
- Cabbage Worm
- Aphids
- Colorado Potato Beetle
- Cutworm
- Flea Beetle

Corn Earworm

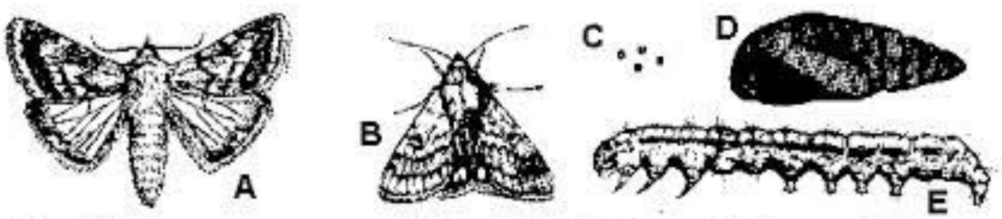
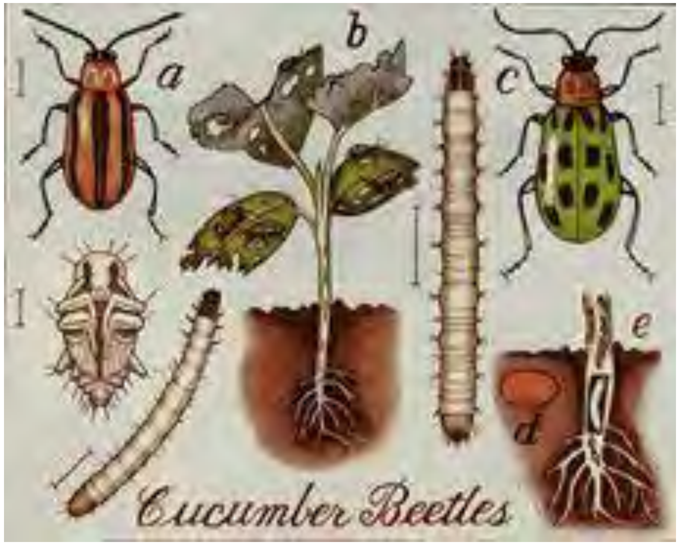


Fig. 79: Corn earworm. A-B, adult. C, Eggs, D, Pupa. E, Larva

- *Range*: From the lower half of Canada stretching to the extreme southern latitudes of southern America
- *Host plants*: Mostly corn and tomatoes. Occasionally found on some bean varieties.
- *Appearance/Habits*: Winters in soil as pupa. Brownish green moth emerges in spring. The moth then lays several thousand eggs on hosts. Several generations are possible in a season. Larvae burrow into cob through silk leaving tunnel of excrement in path.
- *Control*: Planting marigold near corn is helpful. Mineral oil applied to browning silk at tip of ear is helpful. (one dropper per plant maximum)

SQUASH BUGS

- *Range*: Common throughout the US from Central America to Canada.
- *Host Plants*: Squash bugs attack all vining plants, congregating enthusiastically on squash and pumpkins.
- *Appearance/Habits*: Dark brown, sometimes light spotted brown. Hard shell. Three to four inches long. There are five nymph stages before the adults appear in eight weeks. Leaves eaten by squash bugs begin to wilt, blacken, and die. Smaller week plants may be have 40 percent die off rate.
- *Control*: Companion planting with radishes, nasturtiums and marigolds is beneficial.



Striped/Spotted Cucumber Beetle

- *Range*: Native to United States and from Mexico to Canada.
- *Host Plants*: The striped cucumber beetle is a pest of the cucurbit family. The spotted cucumber beetle is a much more general feeder effecting up to 250 different vegetables, flowers, weeds and grasses.
- *Habits*: Cucumber beetles affect the garden host plants in numerous harmful ways. They feed on all portions of the host. They can carry cucumber wilt as well as mosaic virus.
- *Control*: Protect transplanted starts with Remay. Straw mulch can slow spread of adults considerably. Predators of cucumber beetles include braconid wasps, nematodes, and soldier beetles.

Cabbage Worm

- *Range*: Imported worm/moth arrived on this continent in the late 1800's and can be found throughout the US.
- *Host Plant*: Specializes in members of the cabbage and mustard family but can also be found in other brassicas and some lettuce.
- *Appearance/Habits*: Springtime when temperature becomes warm enough pupa hatch into white butterfly with three or four black spots on their wings. Butterflies lay yellow oval shaped eggs hatching into soft green caterpillars. Caterpillars eat large uneven holes in foliage. They feed for roughly three weeks and pupate. There can be as many as five generations in a season.
- *Control*: Companion plant with tomatoes, onion, garlic, and other alliums. Remay can be effective if used early on in the season. Encourage Braconid wasps by planting strawberries near possible host plants or around gardens.

Cabbage Worm Control

Dusting Plants

- Sprinkle damp leaves with corn meal, rye flour or a mixture of one part salt to two parts flour. Cabbage worms that eat this coating will bloat and die.

Handpicking

- Handpicking in the early morning makes a sizable dent in the worm infestation right away.

Badminton Racquet Technique

- The white cabbage moths can be ubiquitous in the home landscape. Kids can be enticed to kill the moth on the fly with a badminton racquet. This technique requires some skill in avoiding damage to garden plants and flowers.

Cabbage Worm Control

Netting or Fleece Cover

You can make barriers from a material that allows sun, air, and rain to get through but prevents the adult, white butterfly from getting access to your plants. Nylon netting, fine screening, or agricultural fleece are all effective barriers, preventing the butterfly from laying eggs at the plant's stem. Cover transplants or newly seeded area with the preferred material immediately after transplanting or seeding so the moth can never get to plants and lay eggs on them. Drape the barrier material directly over the plants and seal all the edges to the ground. Provide lots of extra material so when the plants grow larger they don't strain against the covering.

Pantyhose Cover

Use the stocking part of pantyhose or a regular nylon stocking to cover cabbage heads as soon as they start to form. The nylon stretches as the cabbage grows, allowing air, sun, and moisture in but keeping the cabbage butterfly out.

Cabbage Worm Control Continued

Intercropping or Companions

- In experiments done with cabbage, all interplants or companions tested seemed to attract more moths of the imported cabbage worm into the plots for egg laying then if no interplants had been used. Catnip and tansy were most attractive. Catnip companion plantings also increased imported cabbage worm on broccoli. Nasturtiums demonstrated no effect on imported cabbage worms on collards, although gardeners often recommend them. Tansy interplanted with broccoli actually increased imported cabbage worm larvae. Other research is now in progress, but it appears that many of the customary companion plantings designed to reduce imported cabbage worm have no scientific basis.

Attract Beneficial Insects

- Parasitic (Non-stinging) Wasp - **Braconid** and **trichogramma wasps** parasitize the eggs of imported cabbage worms. They can be attracted to your yard by flowers that look anything like daisies.

http://gardening.yardener.com/Control-Cabbage-Worm-With-No-Insecticides

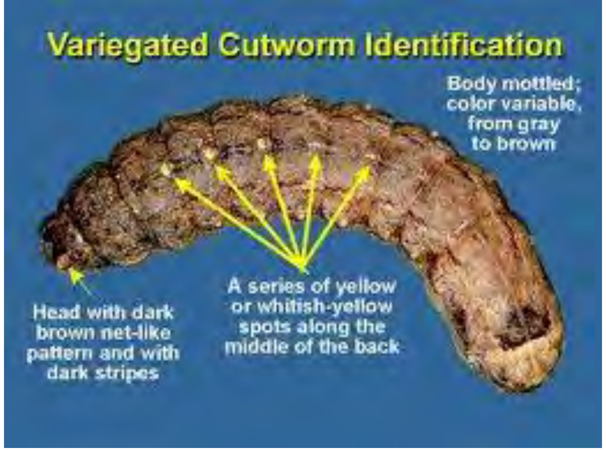
APHIDS

- *Range*: There are many different species of aphids that can be found throughout the United States
- *Host Plants*: Aphids can be found attacking and colonizing on an incredible number of plants. The real garden danger arrives in the form of communicable diseases the aphids can bring to your garden.
- *Appearance/Habits*: Aphids will come in a variety of colors ranging from green, brown, red, yellow, to black. They are generally a wingless soft-bodied insect that colonizes a garden when a few winged aphids land on a suitable host and quickly deposit a number of wingless young on the tender edible part of plants. The young feed on plant sap, maturing in about 10 days, and are ready to produce the next generation. This process repeats until plants become so stressed and weak that winged aphids are reproduced, fly off in search of a new host, and the process repeats. Effected plants decline in overall health until becoming very weak and covered in sticky aphid colonies until eventually die. Large aphid colonies in your gardens will also encourage an unwanted ant population as ants show up to "farm" aphids excretion as a food source. Protecting the aphid colony from natural predators.
- *Control*: Ladybugs and lacewings are the natural predators of aphids but the aphids breeding is so vigorous it generally can out compete the predators. Removing and destroying effected plants is important in control of the general population in your garden.

Colorado Potato Beetle

- *Range*: The Colorado Potato Beetle is a native pest United States and began its destructive reign as the Great Plains east of the Rockies fell under heavy cultivation in the 20's. It has now spread to all parts of the USA east of the Rockies as well as some other isolated pockets.
- *Host Plants*: Potato plants are a favorite of these voracious larvae, but the CPB will enjoy a wide variety of plants in the nightshade family such as tomato, peppers, and eggplants.
- *Appearance/Habits*: Colorado Potato Beetles are large wide beetles growing to ½ " in size. Adults are yellow and black striped hard shell beetles. They will lay an egg mass of yellowish orange eggs on the underside of the host foliage. After the hatch, a large deep red larva will emerge and can very easily skeletonize a plant in little time.
- *Control*: Aggressive hand picking of larvae is EXTREMELY important for control of spread as well as health of infested plants. Once larvae emerge and are established on plant a dusting of wheat germ will be ingested causing bloat resulting in death

CUTWORM



- *Range*: Throughout the majority of the USA.
- *Host Plants*: Cutworms attack a wide variety plants.
- *Appearance/Habits*: Cutworms generally appear as a

plump caterpillar that can vary greatly in color.

They can appear solid or variegated in color, often a greenish black with some stripes. When in moth form they generally are brownish black. They are often recognizable curled up around the base of plants laying in the soil. Cutworms can do severe damage to crops in a variety of ways: They can chew through the stalk of a plant leaving the entire plant toppled from the base. They can climb, eating the fruits and stems, they can burrow, chewing on the root structure, and with Army cutworms they will chew the growth tip of plants before moving on to the next available target.

- *Control*: By turning the soil over in the fall after intense cutworm pressure you can expose the larvae, or you can deeply bury any pupae. Thorough cultivation in the spring after the plants emerge and frequent cultivations through out the season will expose cutworms to predators. Dig around base of plant destroyed by cutworm to find worms responsible. Planting sunflowers as a trap crop around the garden will attract cutworms and expose them for disposal. Wood ashes around the base of plants may be strong deterrent.

Flea Beetle

- *Range*: Throughout the United States.
- *Host Plants*: Flea Beetles will chose various host depending on what variety of beetle is present. Pressure on plants in the Brassicas family can become especially tough as spring turns to the hot summer of Oregon and weed host plants dry up and leave the irrigated garden plants extremely attractive to flea beetles.
- *Appearance/Habits*: Flea Beetles are generally very small shiny black hopping beetles that will jump for safety when approached by the farmer. Its this characteristic that makes Flea Beetles an extremely challenging garden pest to deal with. There plant damage is easily recognizable by the hundreds of small irregular holes chewed through the foliage of weakened plants. It often looks like tiny shotgun peppering on the leaves.
- *Control*: Because of the challenge in catching and killing flea beetles without the use of pesticides, the organic farmer has the best opportunity to avoid heavy infestation by applying a good regimen of diversification, crop rotation, and adequate watering. Under watered plants are more susceptible to heavy populations. There has been some effective control using bug vacuum systems. Early use of Remay may help the spread and heavy pressure.

Beneficial and Predatory Allies

Lady Beetle (Lady Bug)

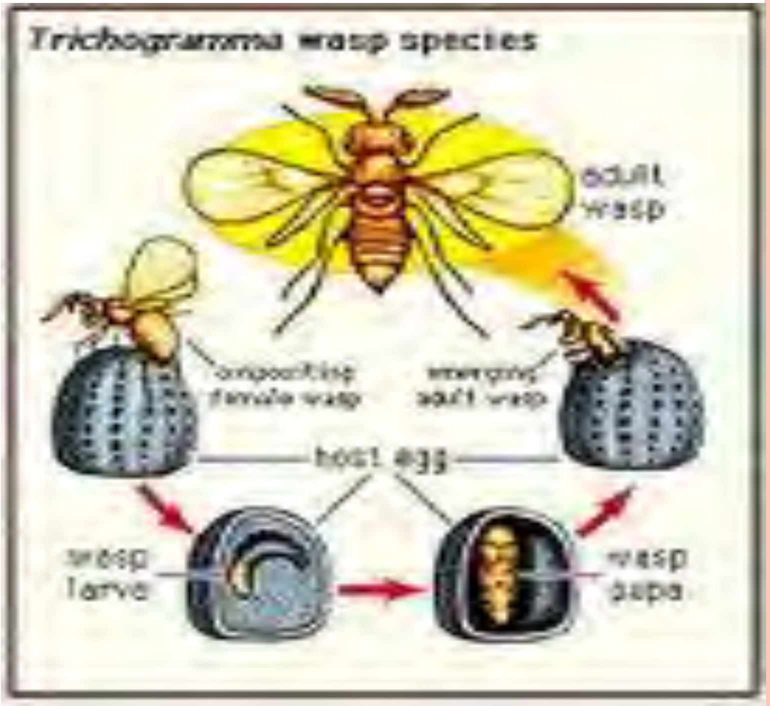
- *Prey/Habits*: The Lady Bug feasts on many small soft-bodied insects such as aphids and spider mites. A single Lady Bug can consume up to 500 aphids a day. They often are most valuable for the farmer or gardener when contained which is why they are often employed in a greenhouse type situation. The larvae of ladybugs are strictly predators, but the adults will sometime feed on pollens and nectars. They are not harmful to plants. Lady Beetles born in the summer time may only live a few weeks to a month however over wintering Lady Beetles can survive up to ten months. The Lady Beetles sold in stores are generally of the variety Hippomania Converges or the convergent Lady Bug. The problem with this variety is they have a tendency to flee the sight. Another drawback is that they are generally incapable of laying eggs.
- A*ppearance*: The larvae are black and longer than the adults with speckled yellow or orange dots on there back. The adults are shiny and generally red with some black spotting on there back.

Beneficial and Predatory Allies

Lacewings

- *Prey*: Lacewings feed primarily on caterpillars, small beetles, soft-bodied insects such as aphids, and some larvae. Both larvae and adults are predatory, and use there modified jaws to suck the liquid inners out of their prey.
- *Habits*: Lacewings will mate and lay their eggs on any surface like windows, sides of homes etc. They will molt several times before spinning a silk cocoon and disappearing to pupate. They will emerge relatively quickly and can go through multiple generations in a season
- *Appearance*: Lacewings are generally a green-bodied long insect with two pairs of wings. Their wings are covered with a lacey veining pattern that is quite delicate. They have large compound eyes next to long antennae.

Beneficial and Predatory Allies



Trichogamma Wasps

- *Prey*: Trichogamma Wasps are amazing predators as they parasitize other insects egg masses. They are known to attack over 150 different insect species such as cabbage loopers, hornworms, cutworms, as well as many different moth larvae.
- *Habits*: Adult wasps seek out eggs following odor. The parent wasp then deposits her egg inside the host egg. Once the wasp hatches, it begins to consume the contents of the egg. The larva then pupates, and eventually chews out of the egg as adult and flies off to locate next host egg.
- *Appearance*: One of the smallest insects on the planet, they look just like larger wasps but are not much bigger than the head of a pin. Wasps have two pair of wings and the females are equipped with a stinger. This is used for probing possible host eggs.

Beneficial and Predatory Allies

Praying Mantis

- *Prey*: The Mantis will eat just about anything that suits its appetite, feasting largely on any insects that happen by. They have been known to eat birds. The mantis will either stay absolutely still and wait for its prey to walk by, or it will slowly and purposefully creep towards its prey. It will then strike out with its folded forelegs, grasping or even impaling its prey. These beneficial garden friends do not differentiate between allies and pests in the garden.
- *Habits*: The mantis is a strange creature with stranger habits. When the mantis mates, the female will often kill the male in the throws of passion. The male can continue to have fruitful intercourse for several minutes after he loses his head. The mantis often sways back and forth when it moves possibly simulating the wind influenced movements of the tree or foliage its hiding on.
- *Appearance*: The mantis is a large insect, measuring from a centimeter being the smallest variety, to the largest being six inches. Most mantises are green or greenish/brown, however tropical mantis can be pink. They have swiveling heads that can turn a full 180 degrees, and their main defense against larger predators is their camouflage. Some mantises have hollow bodies that they use as an echo location chamber to "hear" bat frequencies and therefore avoid being eaten by hurling themselves to the ground.

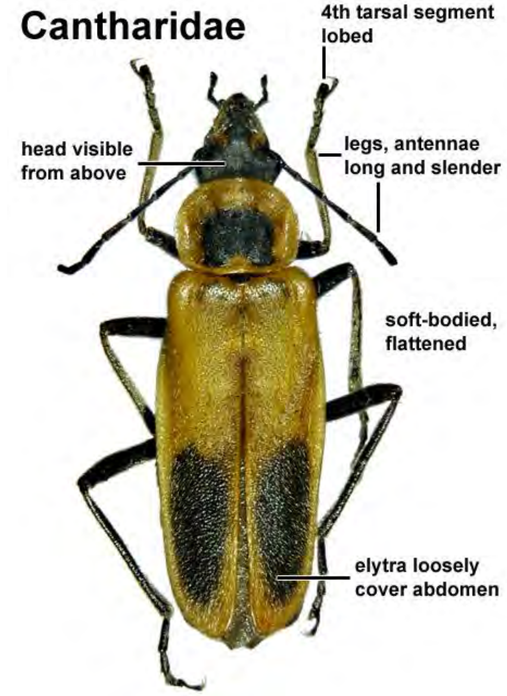
Beneficial and Predatory Allies

Tachinid Fly

Prey: The tachinid fly will parasitize grasshoppers, beetles, larvae, caterpillars etc. They will often take on large hosts such as the tomato hornworm. Some not all species are host specific, only preying on there chosen diet.

- *Habits*: The female tachinid fly will lay her eggs on the host insect skin, however sometimes the eggs will be injected into the body of the host. The larvae then hatch and feed on host insect. Sometimes the host ingests the fly's eggs only to have the fly destroy the host upon hatching. Adults enjoy pollen and nectar as well, and can serve duel purpose in the garden as pollinators.
- *Appearance*: This large fly often will be seen with a blue metallic abdomen. There are over 1400 North American species in the family Tachinidae. Adults have incredibly distinct bristles on the end of their abdomens. They are a similar size to the common housefly but can occasionally resemble bees.

BENEFICIAL AND PREDATORY ALLIES



Soldier Beetle

- *Prey*: Soldier Beetles enjoy aphids, beetle larvae, larvae, and many other common pests. Adults and larvae soldier beetles are both predatory
- *Habits*: Some soldier beetles can be attracted by growing nectar rich flowers in the garden. Adult females lay their eggs in the soil, and larvae emerge shortly there after and begin to feed. Adults will often relax and wait by a good source of pollen, feeding on pollen and nectars until a good prey comes along. The adults will the take advantage of the prey insect that has landed to do the same.
- *Appearance*: Soldier Beetles, (a.k.a. leatherwings), get their name from the soft uniform like clothed appearance of their wings. They're about half an inch in length and generally have a yellow or reddish underbody with brown or black wings. Larvae are velvety in nature with large protrusions from their heads.

Assessment/Review

- Identify a common harmful pest. Discuss its range, host plants, appearance, habits, and methods of control.
- Identify a common beneficial insect. Discuss its appearance, habits, and its prey.

Websites for additional Resources

- http://extension.entm.purdue.edu/
- http://extension.entm.purdue.edu/radicalbugs/default.php?page=home
- http://web.pppmb.cals.cornell.edu/resourceguide/pdf/resource-guide-for-organic-insect-and-disease-management.pdf
- http://www.omri.org/
- http://www.extension.umn.edu/garden/insects/
- http://entomology.tamu.edu/
- http://www.clemson.edu/extension/hgic/pests/plant_pests/veg_fruit/

Permaculture

Moving towards a sustainable society

Objectives

This module is meant to simplify and provide examples for the different aspects of Permaculture, its ethics and principles. It will direct you to media from all over the web, so think of this as a springboard to help you find knowledge; something better than just googling 'permaculture'.

Terms

Functions - work done by elements; conversion of chemical energy, transportation of resources, energy storage, beautification, or elimination of work altogether.

Element - The cause or effect of a function. These can be organisms, machines, buildings, tools, or landscape features.

Resource - any material that is regenerative or replaced in some way over time. As opposed to a source which is not restored over time

Intensive - Something that is complex, information rich and full of energy.

Some Background

Bill Mollison and David Holmgren coined the term "Permaculture" in the mid-1970s as a contraction of *Permanent* and *(Agri)Culture*. The philosophy arose as a direct response to the perceived degradation of ecology, culture, and health in the last century that result from the extractive and controlling processes of industrial society.

The founders of Permaculture

They are both educators and practitioners, and the founders of permaculture as a movement. Each represents a portion of permaculture practice.

- Mollison takes care of the practical side of things. His books are more of a how-to for agricultural practice and are informative and eye-opening. Farmers focus mainly on his work. Much of this module was gleaned from his *Introduction to Permaculture*, which is free http://tcpermaculture.blogspot.com/2013/02/free-e-book-introduction-to.html.
- Holmgren defines the overarching principles of permaculture. His writings are more applicable to society as a whole; to consumers, business people, scientists, governments, and workers. His work is more thought and discussion provoking.

Other Prominent Permaculturalists

- **Masanobu Fukuoka** - Website and Free PDF of The One Straw Revolution(his book that really started it all)
- **Sepp Holzer** - Website , Documentary , Free PDF
- **Toby Hemenway** - Website
- **Geoff Lawton** - Website , he also has an abundance of youtube videos
- **Joel Salatin** - Website
- **Patrick Whitefield** - Blog
- **Maddy Harland** - Editor of Permaculture Magazine
- **Mark Shephard - Author of Restoration Agriculture**

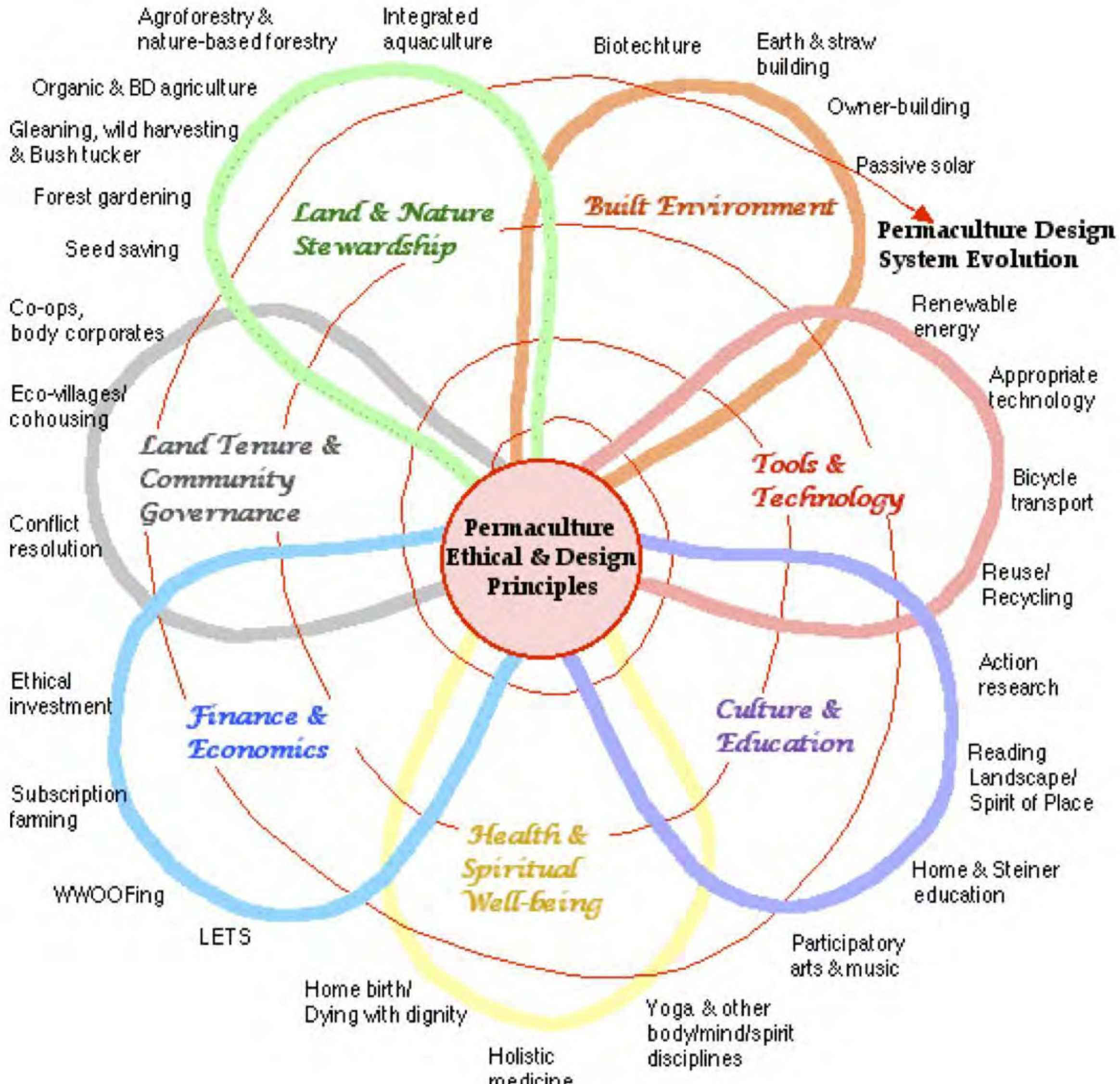
One Definition of Permaculture

- It is a *method* of thinking for designing any system. For some, this extends into systems of culture, belief, business, economics, and ethics.
- Ideally, it is not value based, but evidence based. As in the sciences, the theories and principles are backed by testable evidence found in the natural world. Physics, chemistry, biology, math, economics, government and art all have an equal place in permaculture and vice-versa. Permaculture is about applying information to the design of sustainable systems.

This Blog Post consolidates multiple definitions from leaders in the field. It takes an entire book and years of experience to adequately define permaculture, so it is best to read many definitions as well as write your own.

The Permaculture Flower

Starting with ethics and principles focused in the critical domain of land and nature stewardship, permaculture is evolving by progressive application of principles to the integration of all seven domains necessary to sustain humanity through energy descent.



The focus here is on Permaculture practices relating to Agriculture.

The ***philosophy*** of permaculture is made up of twelve guiding principles. They are elegantly outlined with examples here. These principles were largely developed and written about by David Holmgren, however they are more theoretical and harder to apply directly to agriculture. In this unit, we will be outlining the practical principles of permaculture ***design*** developed by Bill Mollison with relevant examples in agriculture.

A quick list of Design Principles -

1. Relative Location
2. Each element performs many functions
3. Each function is supported by many elements
4. Energy Planning
5. Using biological resources
6. Energy Cycling
7. Accelerating succession
8. Value Diversity
9. Design Small scale and intensive systems
10. Use edge effects
11. Attitude

The Chicken as model

In the following slides, we will be discussing each of the Design Principles, focusing on the Chicken as our model element. We will describe each Design Principle, and then follow by one or more examples that integrate the Chicken element.

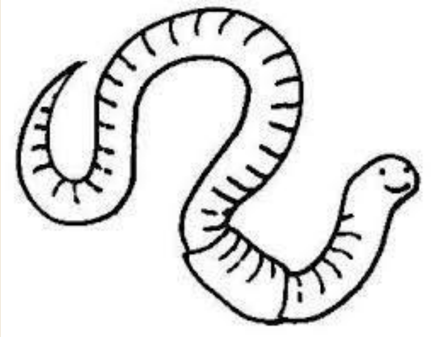
1. Relative Location

This is the core of design. Each element in a system has inputs and outputs(materials); we should locate them *relative* to each other so that materials flow into one another. Relationships between elements are fundamental to the workings of nature, so we should strive to connect the elements of our farm in a way that forms a relationship. We want to make moving materials easy and sensible, allowing energy to flow along the path of least resistance.

1. Relative Location

The kitchen garden loop

Where can we put our chicken??

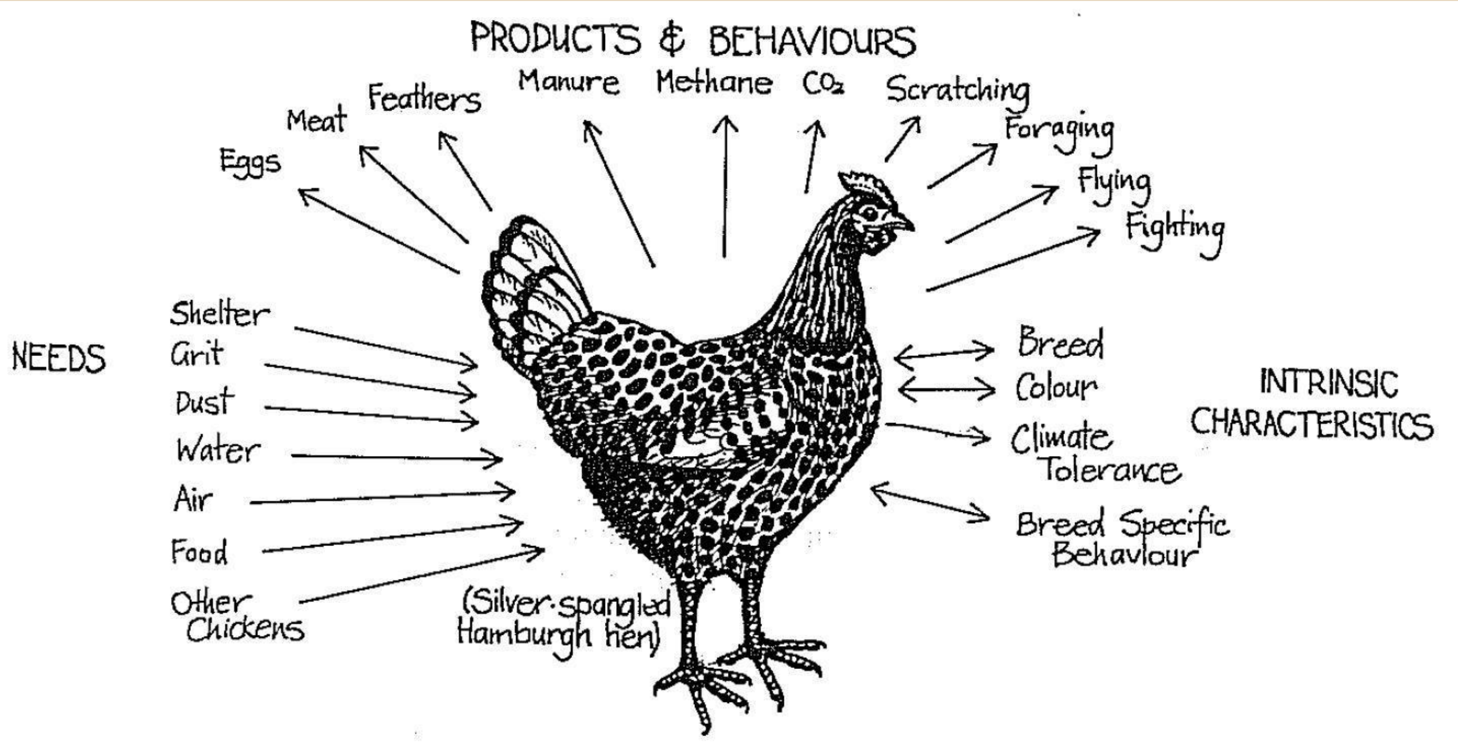


1. Relative Location

A worm composting setup for scraps located between the kitchen door and the vegetable garden allows nutrients to flow easily from table to worms to soil and back to table. Our model element, the chicken, could consume worms that have been feeding on the scraps. These worms can either be given as feed to the chicken at a different location or, if the chicken is allowed access to the worm composting area, in scratching for worms, the chicken turns over compost & scraps, consuming some of the scraps directly; excreting nutrients via chicken manure which add to the available worm food. This is an example of placing one element into an appropriate space between other elements for added products (in this case eggs!)

2. Each Element Performs Many Functions

Everything is multipurpose with a little information and imagination. Every aspect of an element affects how it functions.Our chicken has many elements and functions associated with it. How will we use each of these to our benefit?



2. Each element performs many functions

The Chicken:

- Forages on invasive plant seed and insects, **suppressing pests**
- Converts its food into **fertilizer and food for us**
- **Cultivates the ground** by searching for food

2. Each element performs many functions

This element, the area between the curb and sidewalk has several functions: beauty, insect habitat, plant diversity, soil building and forage.

3. Each Important function is supported by many elements

Pests are suppressed by: chickens, allelopathic plant diversity, wildlife, healthy soil, our intervention

Our food is created by: chickens, crop plants, decomposers in soil(releasing nutrients), compost biology

Land is cultivated by: our implements, our animals(chickens), earthworms, deep rooted plants

4. Energy Planning

Energy planning involves taking your entire land area into account and developing different Zones based on the amount of time/work/input required to manage it. The areas with the highest requirements are near the house (zone 0) up to an unmanaged area (zone 5) used for observation only. We also consider the natural features of the land(contour, vegetation, aspect, weather patterns)

4. Energy Planning

Zone 0	The homestead or home centre. Permaculture principles are applied here to create a sustainable area in which to live and work.
Zone 1	Fully irrigated garden. Personal and household elements which require frequent attention and visits.
Zone 2	Orchards (irrigated) and small livestock. Business and community elements.
Zone 3	Commercial crop, sown pastures and plantations (unirrigated), dams and large livestock. Bioregional elements.
Zone 4	Managed rangeland, forests and wetlands. National/Continental elements.
Zone 5	Untouched wilderness. There is no human presence here, except to observe ecosystems and natural characteristics. Global elements.

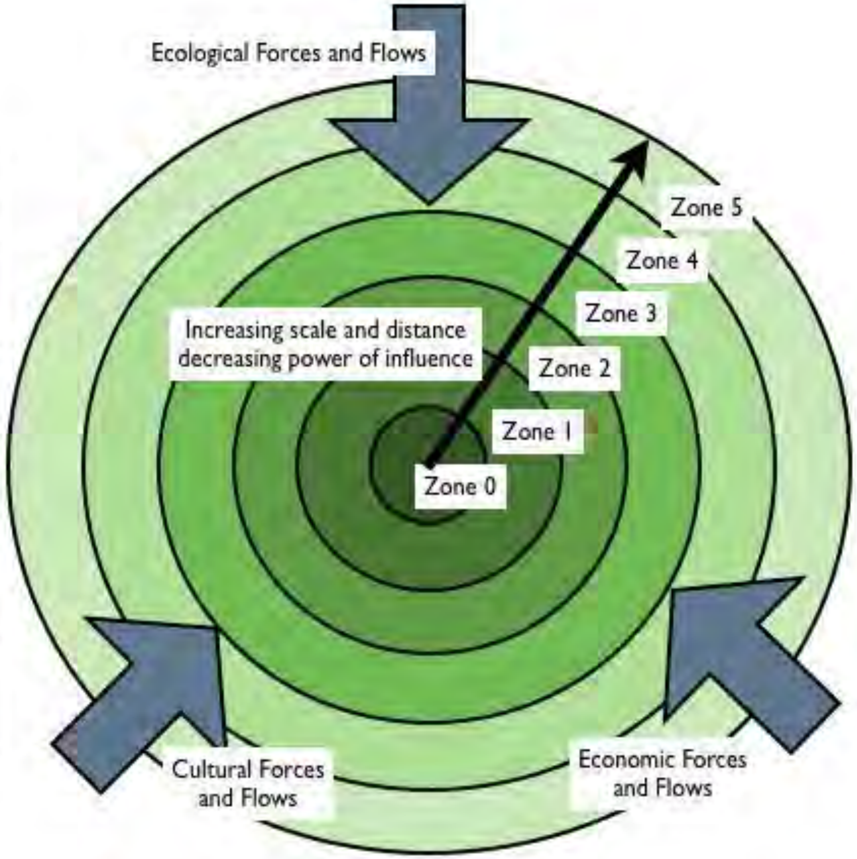
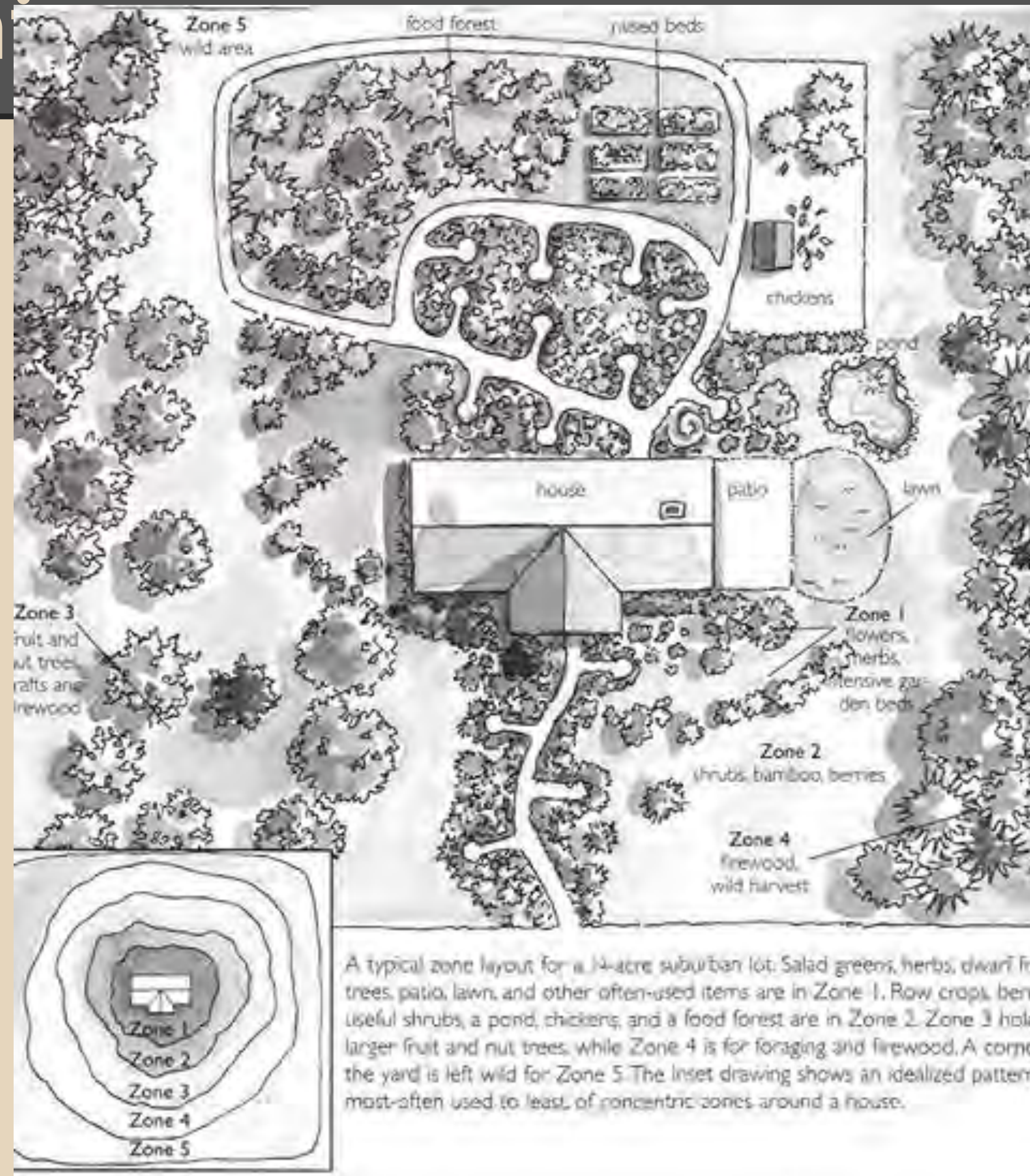


Figure ?. An illustration of the permaculture zone concept together with a table of conventional zone definitions based on site design at a small scale, and on conceptual social connections. Diagram and table were imitated from Holmgren (2002, p. xxvii, p. 139).

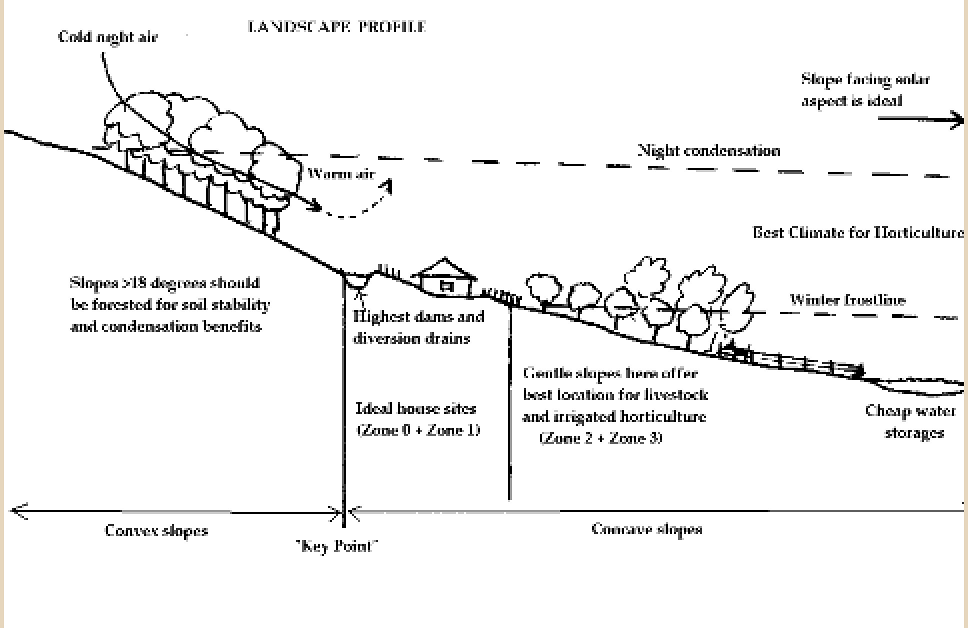
4. Energy Planni

Chickens are located along the daily path, near the house to make caring for them easy and natural. This is design for sectors of land.



4. Energy Planning

We also need to consider slope and contour of the land in profile. These will play a big role in how energy flows naturally. We want to work with this natural flow.



5. Use Biological Resources

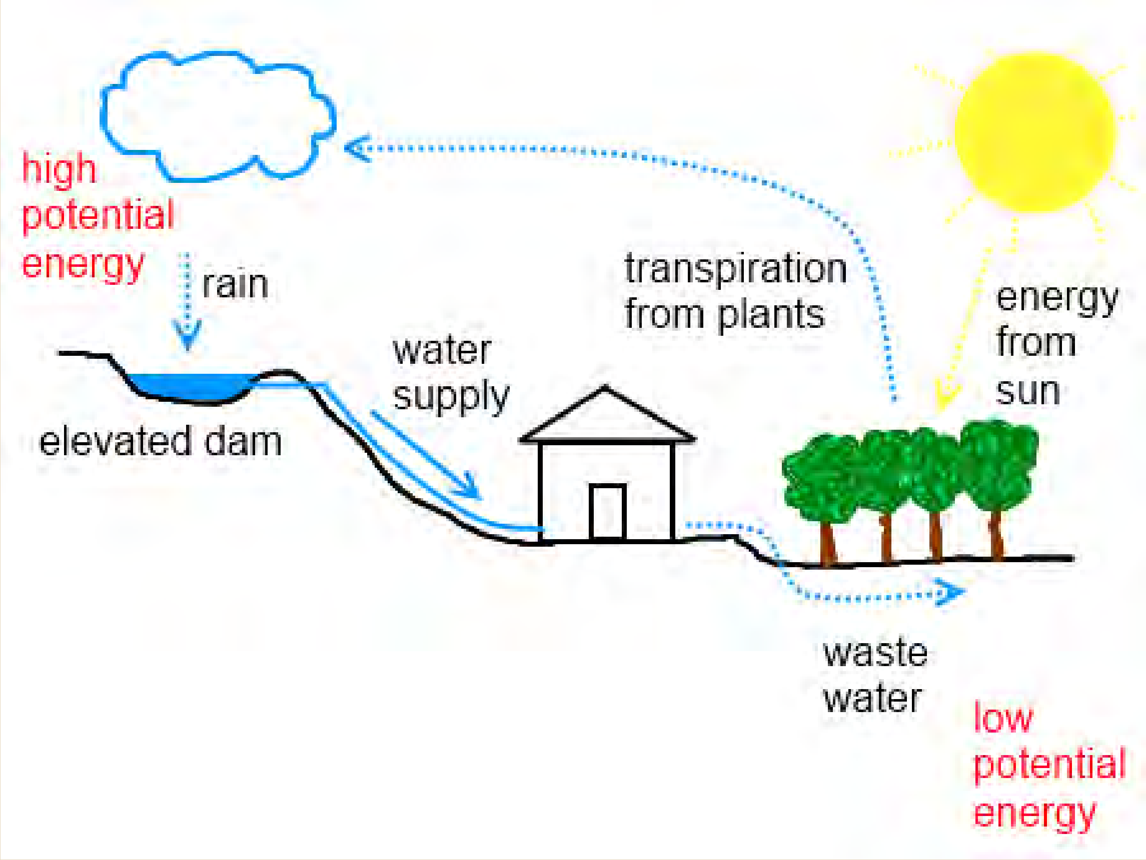
All land has resources present and a careful eye can identify these. These come mostly in the form of plants and microorganisms. Get a field guide and survey your land for useful and edible things.

Hedgerows are often overlooked, but highly useful. Chickens like to nest in this habitat. In the previous slide, we could pen the chickens in a long run on the sides instead of using valuable central space.

6. Energy Cycling

Our food system relies on massive scale extraction of energy(fossil fuels, fertilizers) from the earth. It is a linear sequence of energy transfer that depletes our resources more quickly than they can regenerate. Permaculture seeks to transfer energy in cycles that build resources over time. We must seek to capture and cycle all energy coming through the land. Instead of relying on the manufacture and transport of chicken feed, we seek to provide food on site by planting and encouraging diverse life. Whatever we take, we must return.

6. Energy Cycling



7. Small-scale intensive systems

Small systems require less energy to run and we can stack more of them on a site for diverse yields. Intensive systems rely on lots of information to get them running efficiently, but run by themselves if properly set up. Instead of broad-scale approaches like planting 2000 acres of monoculture, we begin at the area closest to our living space and develop it to a point where it is functioning well with minimal input. We want to maintain control over our environment with as little energy as possible.

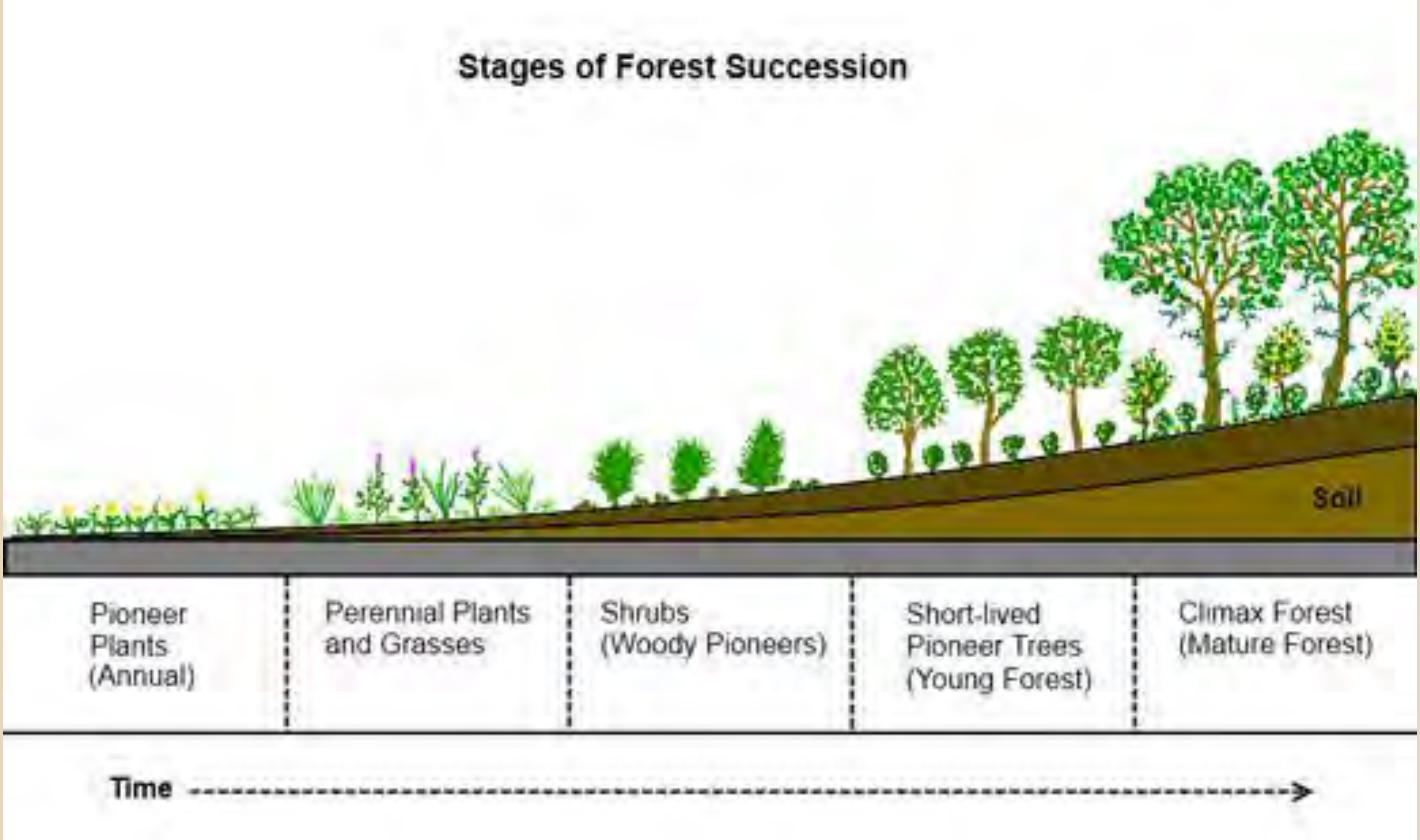
7. Small-scale, intensive systems

- Sepp Holzer's Krameterhof is a great example of how much potential lies in small holdings.
- For chickens, we wouldn’t want to start off with a massive flock even if we have done extensive research. Starting small and really getting to know them will pay off when the time is right to go into larger production

8. Accelerating succession

We understand how stable biological systems are built over time in nature. We can mimic this process successfully and quickly through permaculture design. The goal of permaculture is to build stable ecosystems that produce a yield, usually in the form of multi yielding food forests. This article describes in detail the ecological basis of succession.

8. Accelerating Succession



8. Accelerating Succession

The chicken is best introduced in the young forest stage, where it has perennial ground cover to brood in but also low shrubs in which to roost. Young forests also have abundant insects and seed production.

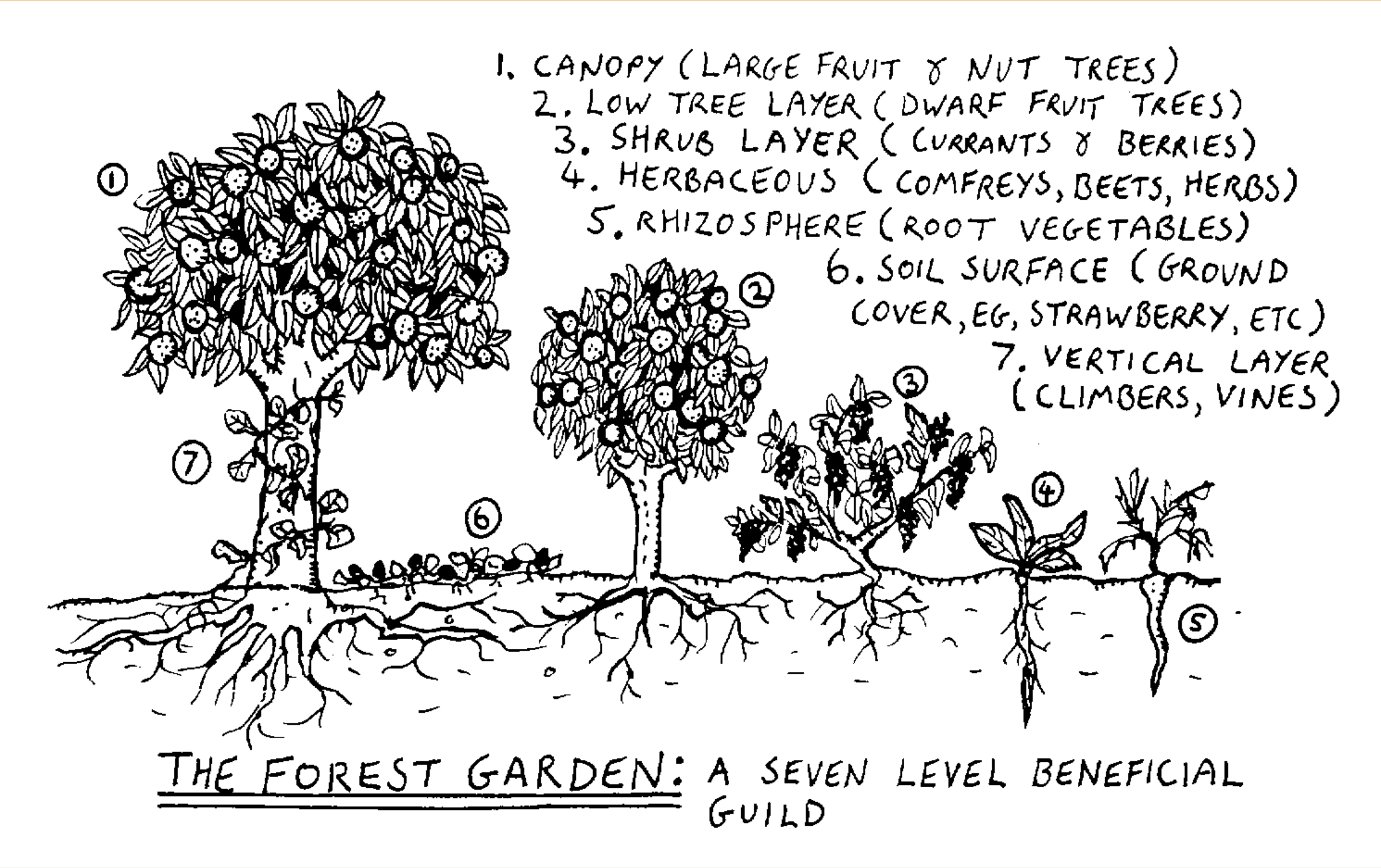
9. Diversity

Diversity is natural and stable. It allows change to occur without detriment and increases production over time. Plants, animals, insects and microbes all work and compete together to form the beauty that we call nature. Knowing the habits of a variety of organisms will allow you to place them together in a system so that they complement one another. This is called a guild because the organisms create an environment allowing for the existence of more complex and abundant forms.

9. Diversity

- Pastures interplanted with trees have been shown to be as productive for grazing as treeless pasture with the added benefit of shade, fruit, nut, or fuel production.
- Our chicken will do best not with a high quality bag of feed and a hut to sit in, but within a guild of bugs, plants, and microbes. It should have plenty to eat and a mosaic of environments to live in. If one type of food or shelter is scarce, there are others to rely on.
- Birds are an important piece of farm diversity. Everything gardens, or has an effect on its environment.

9. Diversity


1. CANOPY (LARGE FRUIT & NUT TREES)
2. LOW TREE LAYER (DWARF FRUIT TREES)
3. SHRUB LAYER (CURRANTS & BERRIES)
4. HERBACEOUS (COMFREYS, BEETS, HERBS)
5. RHIZOSPHERE (ROOT VEGETABLES)
6. SOIL SURFACE (GROUND COVER, EG, STRAWBERRY, ETC)
7. VERTICAL LAYER (CLIMBERS, VINES)
1
2
3
4
5
6
7
THE FOREST GARDEN: A SEVEN LEVEL BENEFICIAL GUILD

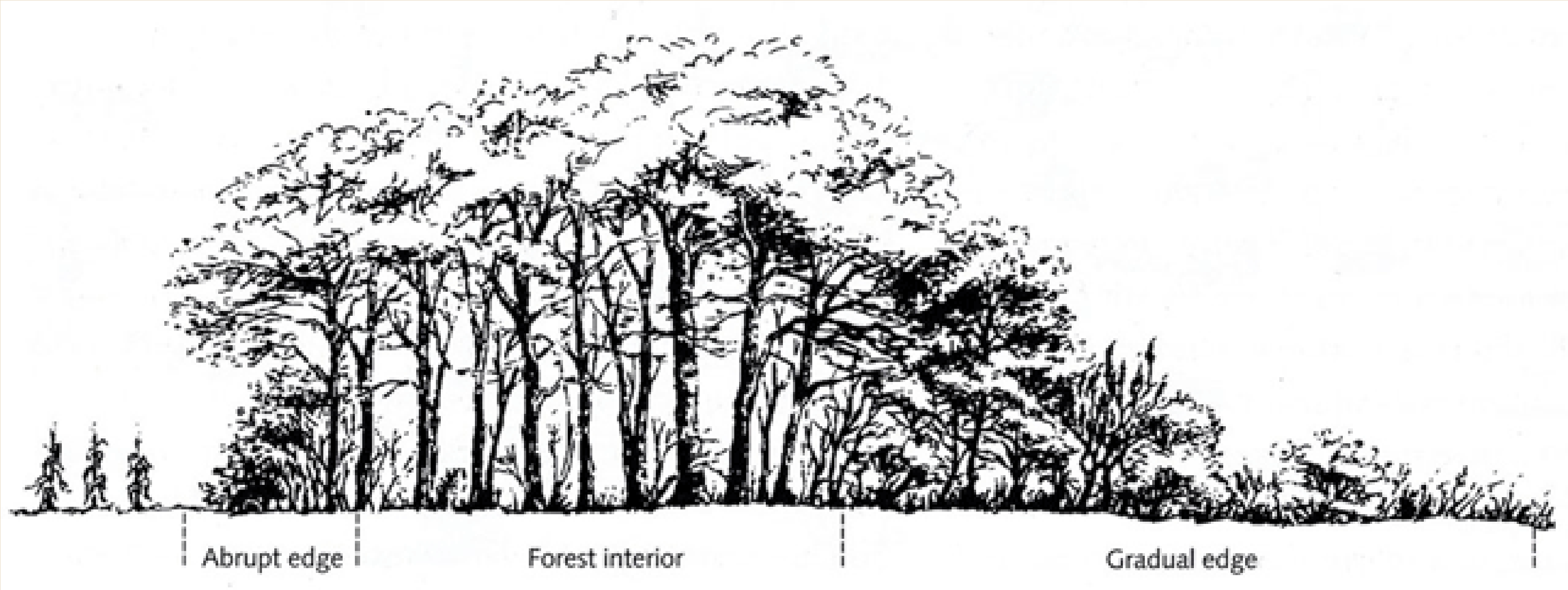
10. Edge Effects

Edges are the interface between two mediums where energy flows back and forth. Life exists as the effect of this flow. Diversity is therefore higher at the edge than in the middle of an area of evenness, where energy is easily immobilized.

The importance of edge

10. Edge effects

This is a diagram only, but you can see the same effect present in nature. The density and diversity of vegetation is highest at the interface between forest and grassland.



11. Attitudinal Principles

Failures are learning opportunities. The negative effects of failure are minimized if we ask the right questions and learn from the mistake.

Experimentation gains you experience, which is necessary to finding the best way to do things.

Every site has an abundance of resources in place in the form of wind, water, rocks, weeds, and wildlife. These resources become obvious with access to the right information

Creativity is the biggest limit to the effectiveness of design.

Chickens are destructive to the ground when penned in densely. If this is our only option, we can use it to our advantage such as clearing ground for planting by penning them in movable structures.

Exercise

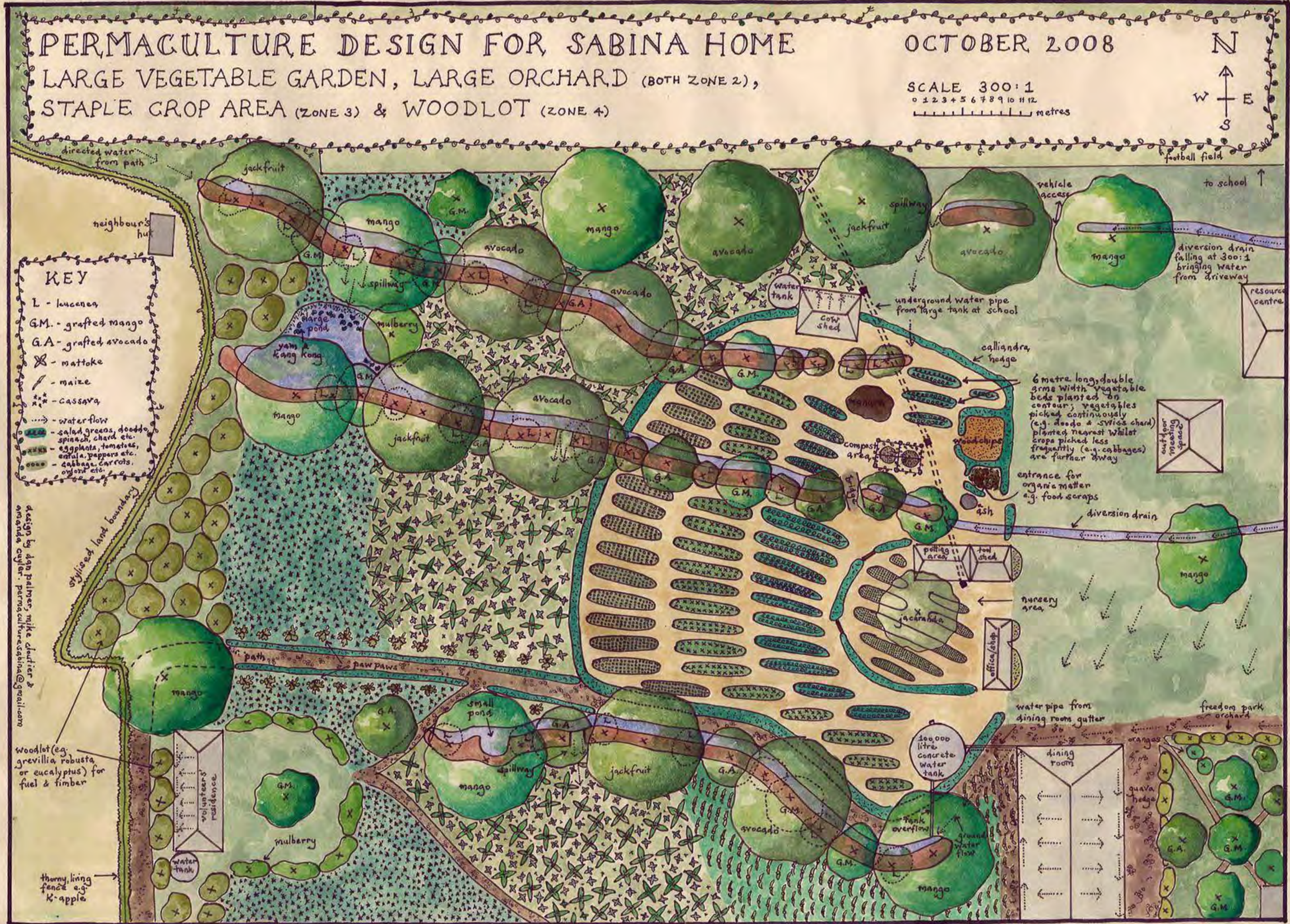
Evaluate the aspects of the following 3 site plans.

-Which one would you pick as the most effective?

-What would you change about it?

-Does the plan follow our guiding principles?

Chicken Run Deer Fence (See Detail)
Removable Barrier
Comfrey + Siberian Pea Shrub
N
chicken Slaughtering
1" = 15'
Vegetative Deer Fence
chicken run
Compost
Espalier fruit trees
Tall
Berries & shrubs
Solar Trap
Tomatoes Peppers
Short
Comfrey Green 'Manure' Garden
Potato Boxes (see Detail)
Wild
Berries
Deer Fodder
Flowers
open
Keyhole Gardens
Trellis
- Hardy Kiwi
- Grape
Patio
Rainwater Collection
Berries
- Blueberry
- Raspberry
Wild
Tool Shed Food Processing Greenhouse
Herbs
Herb Spiral
open
Deer Fence
Jean Pain Mound
Orchard
Espalier Fruit Trees
Snow and vehicles
Exposed Ledge
Access
Apple, Pear + Hazelnut
- Comfrey, Camas, Bergamot, Yarrow, Alliums + Echinacea
Orchard Community
- Apple, Plum + Pear
- Seaberry + Elderberry
- Comfrey, Clover, Garlic chive, Camas, Dill, Fennel, Yarrow, Bergamot, Nasturtium + Chickory
Ledges for
- Walking
- Sitting
- Reaching Fruit


PERMACULTURE DESIGN FOR SABINA HOME
OCTOBER 2008
LARGE VEGETABLE GARDEN, LARGE ORCHARD (BOTH ZONE 2),
STAPLE CROP AREA (ZONE 3) & WOODLOT (ZONE 4)
SCALE 300:1
metres
N
W
E
S
KEY
L - leucaena
G.M. - grafted mango
G.A. - grafted avocado
mattoke
maize
cassava
waterflow
directed water from path
neighbour's hut
football field
to school
vehicle access
spillway
jackfruit
mango
avocado
mulberry
yam & kang kong
large pond
water tank
cow shed
underground water pipe from large tank at school
diversion drain falling at 300:1 bringing water from driveway
resource centre
calliandra hedge
6 metre long, double arms width vegetable beds planted on contour; vegetables picked continuously (e.g. doodo & swiss chard) planted nearest whilst crops picked less frequently (e.g. cabbages) are further away
outdoor meeting space
compost area
woodchips
entrance for organic matter e.g. food scraps
ash
bridge
diversion drain
potting area
tool shed
nursery area
jacaranda
office/shop
path
paw paws
small pond
water pipe from dining room gutter
freedom park orchard
oranges
100,000 litre concrete water tank
tank overflow
ground water flow
dining room
guava hedge
volunteers' residence
stylised land boundary
woodlot (e.g. grevillia robusta or eucalyptus) for fuel & timber
thorny, living fence e.g. K-apple
design by dan palmer, mike cloutier & amanda cuylar. permaculturesabina@gmail.com


Site Plan
1"=100'-0"
fruit tree
red twig dog wood
cornus sericea
lg. berry shrub 6-8′
sm. berry-3-4′
siberian iris
iris sibirica alba
hops vine
humulus
raised garden bed
ground cover
carex "lawn"
forest garden
gravel/patio
FRONT SETBACK
TO LIVING SPACE
CHAIN LINK FENCE
(126′ PLAT)
125.96′
SIDEWALK
75.00′
Area A
Area B
NORTH
FOUND CROSS
TOP OF CURB
125.96′

Self Review

- What are benefits of permaculture for the farmer? For the environment?
- What are the basic principles of permaculture?
- How can your farming plans include more permaculture aspects?

Resources

- Books, Articles, Web Resources by Bill Mollison
- Books, Articles, Web Resources by David Holmgren
- http://midwestpermaculture.com/
- http://www.permaculture.org/

Poultry Management

Learning Objectives

- Understand the role of poultry in a farm system, with an emphasis on chickens
- Learn how to care for adults & chicks
- Learn how to produce eggs, meat, and other products
- Learn about pasture-based production models
- Slaughtering basics

Terminology

- Hen – mature female chicken (> 1 year old)
- Pullet – immature female chicken (< 1 year old)
- Cockerel – immature male (< 1 year old)
- Rooster – male chicken (> 1 year old)
- Molt – natural process of shedding feathers
- Brood – hen that sits to lay egg or cover chick; the action of caring for a chick
- Crop – pouch where chicken digests food
- Vent – opening through which hens lay eggs

Why Raise Poultry?

- Entertainment
  - Growing poultry for competitions
  - Geese and Turkey for Hunting
  - Chicken and Egg Festivals

- Education
  - birds are relatively small animals so younger children can work with them easily

Why Raise Poultry?

- Eggs

Poultry eggs are a regular source of protein and other nutrients that contribute to a healthy diet. The eggs you collect can be used for sale, your own diet, and the shells can be ground up & recycled into the feed as grit. Grit is needed to allow the gizzard to grind hard seeds in the bird's diet.

Poultry Feed mixed with Shell Grit

Why Raise Poultry?

Fertilizer

The manure of poultry is rich in the elements nitrogen, potassium, and phosphorous. These are essential for any garden or crop work. Remember to let the manure cure over time in your compost pile, this prevents nitrogen burning.

Meat

Poultry meat is often one of the main choices of meat sources for human consumption. Broilers & young roosters can be used for roasting, old hens for soup . Excess cockerels can also be used as food for snakes and other carnivores.

Why Raise Poultry?

- Bug and Weed Control
  - Poultry are exceptionally good at eating the unwanted weeds and pests that could harm your desired plants. They must be placed in targeted areas in gardens & fields to avoid harming crops.
- Breeding Stock

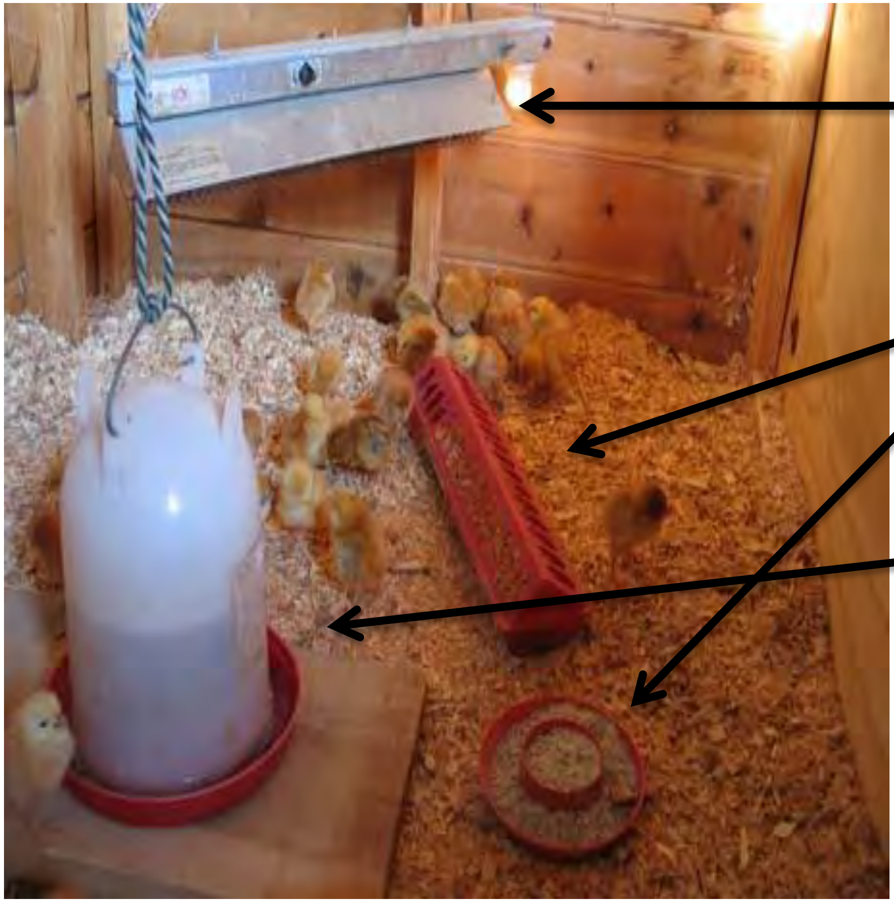
  Some Poultry are kept for the sole purpose of breeding in order to increase your stock and productivity. Most breeders select a specific set of characteristics (i.e. rate of egg laying, meat quality) and breed poultry that have said traits.

Facilities & Supplies

- Feeders
  - trays for chicks and hanging feeders for older birds
- Waterers
  - Similar to the feeders; must be sturdy to prevent being knocked over and should be easily refillable. Put stones in chick waterer to avoid drowning
- Nutrition
  - Provide grit, small size for chicks and larger for older birds. Stream sand provides mineral content as well as physical action in the gizzard. Oyster shell is good source of calcium.
  - Adding hay chaff seeds as well as fresh green vegetable matter is especially important to meet the higher nutritional demand of chicks & laying hens.
  - Consider sprouted grains that you grow yourself; or purchased chick starter for chicks.
- Temperature
  - Chicks require a source of heat. Often heat lamps and heat pads are used to serve this purpose. Heat lamps can be attached inside a brooder for large numbers of chicks http://www.youtube.com/watch?v=cFirvTFcAoY . You can repurpose a leaky livestock water tank in the same way.

Brooding

This image gives us an example of how to set up a brooding area for chicks.



Heat Lamp

Feed Tray and Bowl

Water Source

Chicken Breeds

There are a number of breeds of chickens organized into two groups depending on their type and level of production.

- Meat Production (not limited to)
  - Cornish/Rock cross broilers
  - Jersey Giant
  - Dark Cornish
  - Brahma
- Egg Layers (not limited to)
  - Leghorn
  - Rhode Island Red
  - Buff Orpington
  - Plymouth Rock

Egg Production

- A layer's production often depends on the breed but will normally range from 250-280 eggs/year for chickens.
- Egg color is also dependant on breed
  - White – Leghorns
  - Brown – Barred Rock, Rhode Island Red, Buff Orpington, Black Australorp, New Hampshire Red
  - Brown egg layers range from 150-200 eggs/year.
- Yolk Color
  - This depends on the pigments in the feed. Green plants & food scraps will make the yolks orange while corn & soy feeding results in light yellow yolks.
- Hens start laying at 5-6 months of age.
  - Production rates will decrease as the hen grows older.
  - To maintain profit, replace hens every 2-3 years.

Winter Production

Egg production will decline in the fall and may even cease during the winter months. However by controlling the amount of light the hen receives, laying can continue. Below are two examples of light usage in order to maintain production during the winter.

- 40-60 watt bulb turned on for 16 hours a day: this can be controlled manually or by timer if available.
- 15 watt bulb 24 hours/day: this option does not require a timer or for you to manually track the time of light exposure.

Egg Processing

Once you have collected your eggs from the hen they must be properly cleaned & stored

- Cleaning
  - eggs have a natural antibacterial coating on them called the *bloom,* maintains egg quality in storage
  - If possible, *dry clean* your eggs to preserve bloom. Use a clean abrasive cleaning pad without soap.
  - If needed wash eggs in warm running water, do not soak
  - Keep nest boxes clean to avoid egg washing
- Storage
  - 1 month or more at refrigerator temperature
  - 2-3 months at below 55 degrees at 75% humidity
  - Keep in mind that egg quality can diminish in storage

Meat Bird Slaughtering

Home slaughter of just a few birds

Use upward thrust of tool handle to sever head; or can hang upside down & sever carotid artery with knife

Remove entrails with sharp knife being careful not to nick gall bladder

Pluck feathers or simply peel off the skin

Wash & refrigerate dressed bird and edible organ meats

Also see these videos
http://www.youtube.com/playlist?list=PLsiHfXnYmayiPvVLNZbMPfo23TDXPJOFa

Larger number of birds: use mobile or stationary slaughtering equipment including plucker
http://www.youtube.com/watch?v=jf2ByM_NByI

Chicken Coop Design

There are a number of things that need to be considered when designing a chicken coop.

- Protection from weather such as wind, heat and cold
- Requires adequate ventilation
- Feeders should have 5-6 inches per bird as a general rule while water sources are 1-2 inches per bird
- Roosts should be provide 8-12 inches of roost space per adult and should be separated by at least a foot (12-15 inches)
- Nest boxes are usually a 12 inch x 12 inch structure that is around 2 feet off the ground. 1 box per 5 hens.

Coop Styles

- Mobile (free range pastured poultry)
  - Can be adjusted to change locations to access fresh vegetation
  - Birds need to be trained to go inside at night in new locations
  - Need to protect birds from predators
- Stationary
  - Creates a permanent home for birds with an unchanging location
  - Often more durable
  - Easy to train birds to roost at night
  - Birds will kill surrounding vegetation

Disease Prevention

- Sanitation – cleaning up coops, roosts, and nests on a regular basis in order to prevent contamination of the eggs and illness for the poultry.
- Adequate Space – provide enough space for birds to roam and be isolated if need be. This decreases the chances of a disease from spreading from bird to bird.
- Fresh air and ventilation – utilize air and gas exchange to remove excess heat, dust particles, moisture (products of normal activity), as well as any harmful gases and disease-causing organisms that my be present. Oxygen-rich air promotes optimal production.

Disease Prevention

- Proper Nutrition
  - What you feed and how much will influence your production results. Be sure to have a balanced diet that includes all types of nutrients. See http://www.ag.auburn.edu/~chibale/an12poultryfeeding.pdffor a more in depth description of poultry feeding.
- Culling
  - Culling means to eliminate birds with undesirable characteristics; or those which have passed prime laying age. Cockerels should be culled young for best eating.

Geese have few problems with disease or predators and are great on pasture

Toulouse goose

Protect from Predators & Pests

- Provide your poultry with a coop that is inaccessible to predators such as raccoons, hawks, weasels, and coyotes. Use electric fencing.

- Remember to protect against pests such as lice, ticks, worms, and mites. Turkeys are susceptible to blackhead disease http://www.michigan.gov/dnr/0,4570,7-153-10370_12150_12220-26481--,00.html if raised on ground that has had chickens. Black Spanish heritage turkeys are more resistant.

Black Spanish tom

Pastured Poultry Production

- Feed requirements drop anywhere from 30-50% if your poultry are given the opportunity to roam pasture.
- Housing options:
  - Eggmobile (henabago)
  - Hoop Houses
  - Variation on chicken tractors

- Ensure coop is moved at frequency to allow vegetation to regrow
  - can use electric fencing to contain poultry & discourage predators
- Keep vegetation height low enough to avoid trampling by the poultry
- Rotation can be done along with other livestock

[Pastured Egg Production]

Pastured Poultry Processing

- Requirements for Federal Inspection
  - FSIS overseas and licenses facilities
  - Inspects birds themselves
- Exemption from Federal Inspection
  - Under 1000 birds per year
  - All poultry must be raised on producer's own farm
  - Producer may not buy or sell offsite birds
  - No poultry is distributed outside state
- Check State Laws
  - Some states limit open-air slaughter of poultry for sale
  - Usually exempt from state laws if customers buy directly from farm

Marketing

- Meat – Thanksgiving turkeys increasing in demand. C breeds.
- Eggs: Direct vs. Retail
  - Designations: certified organic, free-range, free-nested, cage free
  - Must obtain egg license in most states to sell at farmer’s markets

Spotlight on Permaculture

> Hatch your own chicks rather than ordering from a hatchery

--Certain breeds such as Silkies are good setters & will hatch eggs readily

--Provide properly sized & designed nest boxes

> Use chickens in a managed way to cultivate garden areas

> Vermiculture --Construct worm bins inside greenhouse, fill with manure and other compostables --rotate poultry through bins

http://www.themodernhomestead.us/article/chickens+in+greenhouse.html

Assessment Review

- What role can chickens play in an agricultural ecosystem?
- What are the benefits of pastured poultry production models?
- List important considerations for care of chicks.
- What are the basic feed requirements of chicks? Chickens?

References

- ATTRA (Appropriate Technology Transfer for Rural Areas) http://attra.ncat.org/
- The Chicken Health Handbook. Damerow, G. 1994, Storey Books, North Adams, MA. 344 pp.
- Pastured Poultry Profits. Salatin, J. 1993, Polyface, Inc, Swoope, Va. 371 pp.

Sources for Chicks

- Phinney Hatchery, 1331 Dell Ave., Walla Walla, WA
- Murray McMurray, Webster City, IA

Beekeeping

Learning Objectives

The learner will…

- Understand the basic life cycle of the honeybee
- Learn about beekeeping tools and equipment
- Learn to manage beehives for honey production and pollination
- Learn about bee diseases and pests
- Learn to harvest and market honey

INTRODUCTION TO BEEKEEPING

The first step in becoming a beekeeper is deciding if you actually want to be one. It would be a shame to commit your time and money only to discover that you really don't enjoy it.

There are several ways to figure this out:
(we recommend you do all of these)

- Read literature on the subject,
- Attending local, district or state beekeeping association meetings,
- Attending beekeeping educational classes
- Visit beekeeping websites
- Establishing a relationship with an experienced beekeeper.

Beekeeping Terminology

- Apiary: A bee farm is an apiary, and a bee farmer is called a beekeeper.
- Brood/ Larvae: Young bees before metamorphosis
- Brood chamber: The box in which the queen bee lives and lays eggs. Where young bees are raised.
- Colony: A large group of bees that live in a hive.
- Comb Cell: Where bees store honey and pollen and also where queen bee lays eggs.
- Drone: Small male bees. There are very few drones in a colony. Their job is to mate with the queen bee.
- Frame: As the name implies, each of these components "frames" a beeswax comb, giving it rigidity and strength and uniform shape.
- Hive: Home for bees made up of several boxes each box is filled with frames and has two covers that keep out rain, snow, dirt and animals. The bees make their combs on the frames.

- Hive stand: Keeps the hive off the ground so that it does not get too cold or too wet.
- Hive Tool: Tool used to pull apart the sticky frames.
- Honeycomb: A wax structure built by bees, made up of six-sided cells.
- Honey Supers: Wooden boxes where the worker bees store honey.
- Queen Bee: Leader and mother of the bee colony. The only female that can lay eggs.
- Queen Excluder: Heavy gauge wire panel placed on top of honey supers that keeps the queen bee in the brood chamber and stops her from laying eggs in the honey supers.
- Smoker: A device used to spray light smoke into the hives. The smoke calms the bees so they don’t sting.
- Swarm: A group of bees that have left the hive to form a new colony.
- Worker Bee: The majority of the colony are worker bees. Female bees that cannot lay eggs. Younger worker bees are called house bees. They clean the hive, make honey, and care for the younger bees. Older worker bees are called forager bees. They gather food for the colony and defend the hive from enemies.

Who's in a Beehive?

A Honeybee Colony or Hive consists of :

- Queen : Lays fertilized eggs reared in a special cell called a "queen cell" and fed royal jelly by nurse bees, only 1 adult queen per colony, hive cannot continue without queen, queen can lay worker or drone eggs
- Drones- Male bee, mates with queen, can not sting, develop from unfertilized eggs
- Brood- Young bee larvae
- Workers- Female bees, sterile, perform sequence of jobs as they age
  - first half of life: cleaning brood cells, cleaning the hive, feeding older larvae, feeding younger larvae, taking orientation flights with young bees, evaporating nectar, building comb, feeding queen & drones, keeping an even temperature in brood nest, and guarding entrance to hive.
  - The last half of life is spent foraging for nectar, pollen, water, and propolis materials (bee glue) outside hive.

The Apiary

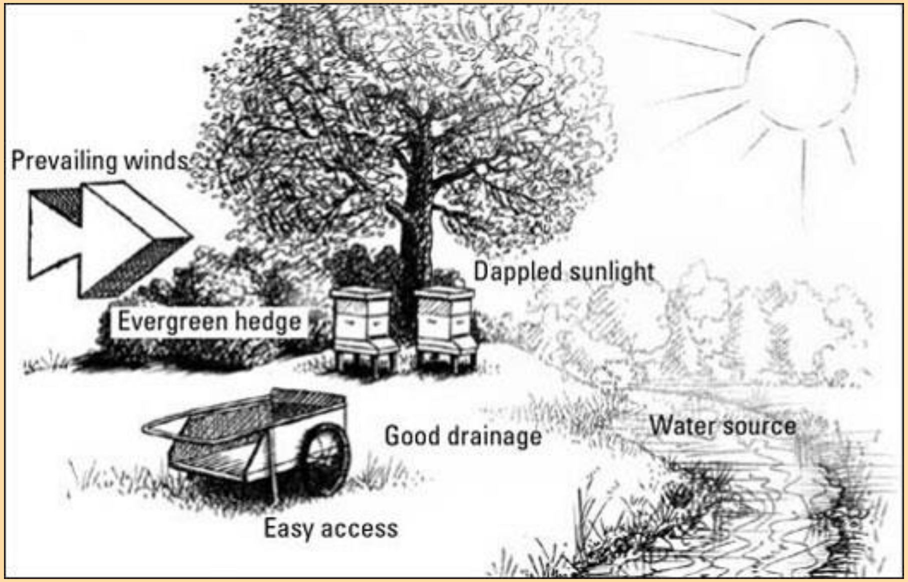
•Honeybees are social insects.

•Colonies can grow to more than 60,000 bees.

•Bees pollinate fruits & vegetables, and produce honey & beeswax.

•Keeping bees is a specialized skill requiring familiarity with the seasonal rhythms of the honeybee life cycle.

•It is almost always necessary to spend time with a mentor beekeeper to learn what is involved.

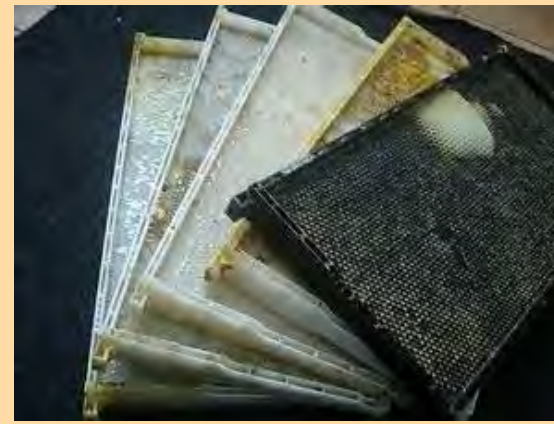


Situate your beehives in a protected sunny location (they prefer eastern exposure) with source of clean water, nectar sources, and good drainage.
Startup considerations

What’s in a beehive?

Beehive consists (from top to bottom) of outer cover, inner cover, honey supers, queen excluder, brood super(s), bottom board, and hive stand. Supers contain wax filled frames separated by bee space (1/4 inch – 3/8 inch).

Queen Excluder used to keep queen in the bottom of the hive.



Wax Filled Frames used by bees to store honey. These are plastic but you can construct your own wood frames:

[Frame Assembly]

Managing frames using a hive tool

Clothing: Bee Suits/Boots/Gloves

Choose loose-fitting, light colored, long pants and long sleeves with a smooth finish. Wear boots that come over the ankle. Secure the bottom of pants over the boots and the sleeve cuffs with straps, tape or rubber bands to prevent bees from entering.

Gloves should fit well otherwise they will make you clumsy and may increase stinging. Experienced beekeepers do not wear suits or gloves most of the time, but these can be valuable for the beginner beekeeper!

Veils/ Helmets

A veil should be worn to avoid stings on the face, especially near the eye, in the nose and in the ears.

- Types of veils: detachable including folding & round; worn over helmet & secured in place with drawstrings tied around the waist
- Zip on style, nylon or wire mesh that zip onto a coverall.

Tools

- Hive tool used to pry apart supers & frames
- Brushes used to brush bees off of the frames
- Scrapers used to open wax cells during honey harvest

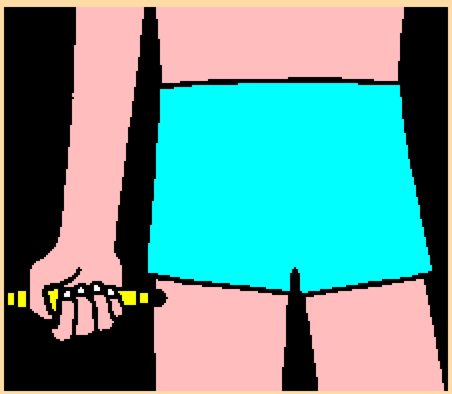
Smoker

Smoke:
- Masks alarm pheromones
- Triggers instinct to retreat to hive
- Bees may believe hive is on fire & gorge with honey in preparation for leaving. This makes them slower and less able to sting.

When smoking a colony, position the smoker spout a few inches away and use small puffs of smoke.

Smoker fuel can include wood chips, bark, twine, or straw

EpiPen Auto-Injectors



In case of emergency, due to an allergy to beestings or multiple beestings, always have available EpiPen Auto-Injectors handy for both adults and children. Each pack comes with a practice pen and two live injectors.

Getting your bees

If you want a hive to be productive, start it in late spring or early summer. You can start by:

1. Ordering a Package- a 3 lb package is about 12-13,000 bees. There are a few different ways to install a package. Pierce the candy that plugs the queen cage with a nail, place her securely in the hive. Remove several frames before dumping in the bees, then replace frames.

2. Obtain a split or divide from another beekeeper (more later on this). There will only be a relatively small number of adult bees and a large number of brood cells; so make sure the temperatures are warm enough for the adults to cover (warm) the brood.

Types of bees- Russian Italian Carniolan Caucasian Buckfast

Working with Hives

• Put on a suit and light the smoker.

• Work with slow, steady movements.

• Come to terms with stinging insects flying around you; remain calm. If you get stung or get scared walk away from the bee area.

• Leave colony open for as little time as possible.

• Inspect the colony for appropriate activity dependent on the season.

• Pay close attention to your mentor beekeeper to learn the needs of the hive.

A Healthy Brood Frame

Inspect the brood frames for healthy larvae (they should appear white). Look for eggs standing in the bottom of cells and for cell caps which will be convex and tan. Also, look at the pattern of the cells with brood. The pattern should be compact and in a semicircle with very few skipped cells and usually on the bottom half of the frame.

Unhealthy brood are often concave and perforated with small holes because the worker bees chew them. Gray, yellow, brown or black larvae are diseased, chilled or injured.

Burr Comb

Remove burr comb as you work bees and save wax in a clean container to melt and sell.

Dividing Colonies: Making Splits

- Gain additional colonies to increase your apiary.
- Downsize a hive that has grown too large and become unmanageable.
- Prevent swarming- to almost completely eliminate the possibility do a walk away split
- Make splits in spring (usually early April) after bees replenish population but before becoming overcrowded.
- Use queen cells or eggs which workers will turn into queens.
- Include frames with brood, pollen, & honey, as well as adult nurse bees.
- Splitting/swarm prevention This video shows a pro in action but make sure you add a queen, queen cells, or eggs to your split

Swarms

Active swarm in tree

- Natural mode of reproduction in honeybees
- Usually consists of an old queen and 50-60% of the worker bees in swarming colony
- Great source of bees for a new hive
- Methods for collecting swarms vary

[Hiving a swarm]

Cutting down swarm

Hiving swarm

Honey Harvesting

- Look for capped frames- honey covered with thin layer of wax
- Gently smoke bees avoiding frames of honey
- Shake or brush bees from frames and transfer frames to an empty super
- Use heated uncapping knife to melt wax cappings, centrifugal turning extractor to spin honey out of frames. Filter & collect in clean containers
- Allow bees to clean frames then store. Protect empty, stored frames from wax moths.

•Honey Harvest

Overwintering Beehives

Insulated top

Entrance reducer

- Prepare colony for cold weather by ensuring bees have enough honey. At least 50-60 lbs of honey per colony is suggested.
- Place insulated top & surround with hay bales, bagged leaves, or tar paper.
- Protect from mice by placing entrance reducers.
- Minimize inspections during cold weather as bees go into their clusters.
- Manage air flow-air circulation is needed.
- Feed with sugar or honey during early spring if a very cold winter.

Pests & Diseases

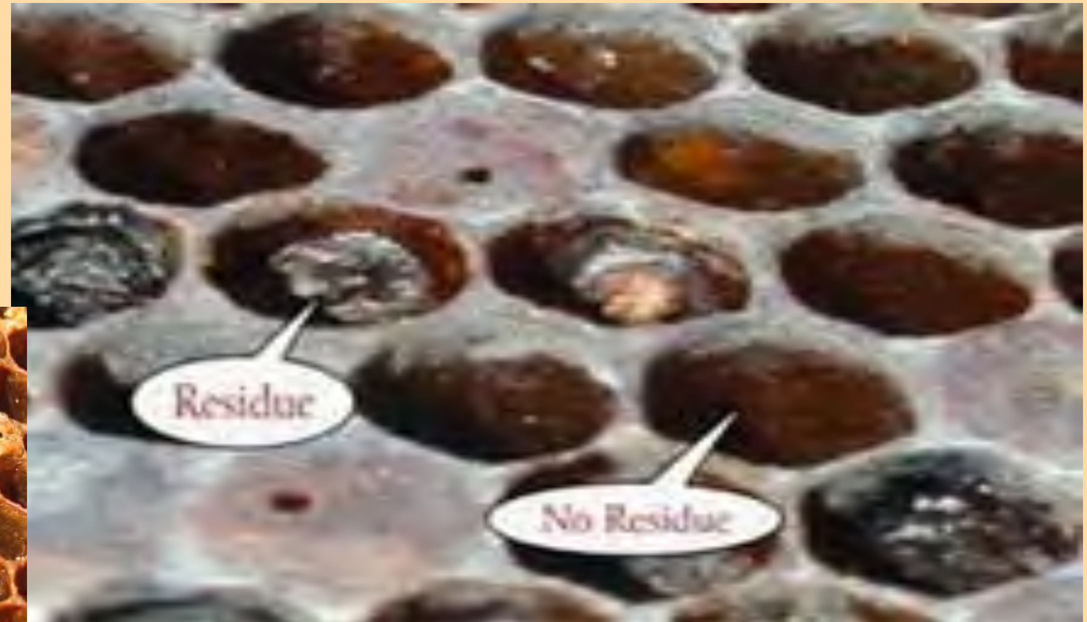
American Foul Brood

Varroa and Tracheal Mites

Small Hive Beetles

Small Hive Beetle

- Larvae destroy hives. Use oil traps in active hives; freeze stored equipment.
- Beetle Top Trap Bottom Trap
    - » Fill traps with liquid oil



American Foul Brood

- Spores can remain in wax, honey or in the wood of the hive box.

- While used hive equipment is economical, the danger of acquiring foulbrood must always be considered.

Varroa Mites

- Varroa Mites are external parasite of bees, European honey bee is a new host & so has no natural defenses
- Mites feed on the larvae especially drones
- Pesticide treatments have resulted in resistant mites
- Some bees have become resistant to mites, powdered sugar dusting forces bees to clean themselves, dislodging the mites. Can also use screened bottom boards.

Tracheal Mites

- Tracheal Mites live in breathing tubes of bees. Menthol & formic acid treatments are low toxicity treatments

Spotlight on Permaculture

Top Bar Beekeeping

Top Bar Beekeeping is an alternative/low cost method, suitable for home production. Not ideal for commercial production of honey because of the greater difficulty in separating the honey from the comb/wax.

Bee Poetry

“A swarm of bees in May is worth a load of hay. A swarm of bees in June is worth a silver spoon. A swarm of bees in July isn’t worth a fly.”

Self-Review Questions

- What needs to be done to keep beehives over the winter?
- What is the best way to learn how to work with bees?
- Where are other resources available?
- What safety and emergency equipment is important to use and keep on hand?

References

- Beekeeping in Indiana by Steve Doty
- Beekeeping organizations – Indiana State Beekeepers Association; Indiana Beekeepers Association; Michiana Beekeepers Association; Michigan Beekeepers Association
- Backyard Beekeeping- Kim Flottum, ed. of Bee Culture magazine
- First Lessons in Beekeeping- Keith Delaplane
- Hooray for Beekeeping! – Bobbie Kalman
- How to Keep Bees and Sell Honey – Kelleys
- The Hive & the Honeybee - Dadant

CONSERVATION PRACTICES

Learning Objectives

The learner will...

- Understand the importance of conservation practices
- Learn about common effective conservation practices
- Acquire knowledge about conservation practice installation

Terminology

Conservation: refers to the wise use, improvement, and protection of our natural resources.

USDA: United States Department of Agriculture

NRCS : Natural Resources Conservation Service. A division of the USDA that helps farmers with conservation projects

Permaculture: the development of agricultural ecosystems intended to be sustainable and self-sufficient. (See also Permaculture module)

Ecosystem: interconnected system of living organisms (plants, animals, & fungi/bacteria) in their environment

No-till: planting seeds without disturbing the soil

Organic Farming + Permaculture
The ultimate in conservation and sustainability

The heart and soul of organic farming is caring for and maintaining the soil. Organic farming minimizes soil disruption and uses nature for pest, disease, and nutrient management. Improving soil health results in greater water infiltration, which leads to less runoff & erosion. However, organic farming for single crop annuals alone is not sustainable in the long run.

An agricultural system based on permaculture design closely mimics nature emphasizing perennial crops and native plantings. We will discuss the specific conservation practices that are most applicable in a permaculture designed farm; yet allowing for harvest of annuals to support farm income.

Conservation practices on farms are the specific tools for improving the health of the soil, water, & air. Cost sharing is available through the NRCS on qualified farms to offset some of the farmer's upfront costs.

Permaculture practices visible here include mulching, cover crops, drip irrigation, wind power, wind breaks/forest, prairie, & pasture. Most of these elements are Conservation Practices as defined by the NRCS.

Conservation practices common in Permaculture

- Water conservation Methods
  - Irrigation Scheduling
  - Soil Management
  - Water Harvesting
- Soil Conservation Methods
  - Contour Buffer Strips & Filter Strips
  - Mulching
  - Nutrient Management
  - Cover Crops
  - Heavy Use Area Protection
- Environmental Conservation Methods
  - Windbreak
  - Hedgerow Planting
  - Integrated Pest Management
  - Prescribed Burning
  - Forest Stand Improvement
  - Pollinator Habitats

no-till soybeans in rye cover crop

oak savannah

Water Conservation

Water is the source of life for any farm. Some direct uses for water include drinking, irrigation for farming, and livestock watering.

- Water conservation is of utmost importance, especially during times of drought.
- Collecting and storing water through an efficient water capture system can save time, money, and effort.
- Water capture systems can include rainbarrels, ponds, ditches, and swales (see also Permaculture module)
- Overuse of groundwater – such that it is not recharging as fast as it is being withdrawn- is not considered a sustainable practice.

Water Conservation Methods

- Irrigation Scheduling
- Soil Management
- Water Harvesting

Irrigation Scheduling

The most sustainable irrigation systems use captured rainwater. This supply will necessarily be limited; therefore deciding when and how much water to apply to a field will conserve water for when plants really need it. Pay attention to the amount of water that each individual crop needs to survive and thrive.

Black eyed peas need less water than cucumbers

Pay attention to the weather.

Whatever water supply you are using, don't put your watering system on a timer and let it go everyday. If rain isn't providing enough moisture, your drip irrigation system will keep your plants happy during the time when water is less available. For a detailed study of installation procedures into raised beds see Part 1 Reaganite; Part 2; Part 3. (See also Irrigation module)

Soil Management

Properly managing your soil can be an extremely effective way to reduce losses of water. If the soil is healthy & contains organic matter it be able to ***hold, absorb***, and ***transmit*** large amounts of water.

There are several ways to manipulate and improve the nature of your soil to work towards your benefit. These practices help to increase organic matter in the soil in an integrated system.

Composting

Create your own fertilizer

Cover Crops

Legumes take nitrogen from the air and put it in the soil

Conservation Tillage

Includes no-till & reduced tillage

Weed the Soil Not the Crop, plant a mix of crops, and Rotate!

See corresponding modules for more detail on these topics.

Water Harvesting

Water harvesting can 1) collect rain for direct use in garden areas & to water livestock, and 2) direct runoff into areas where it can be stored and then slowly released for larger planted areas, pastures, fish, & wildlife.

If you want to catch and store rainwater from a roof, storage tanks are a reliable method of water conservation. A storage tank is a relatively easy system to install.

Tank

Gutters

Slanted roof

Rainwater that falls onto a catchment surface (such as a roof) is allowed to drain into a distribution system (the gutters) which leads into a tank that stores and maintains the water for later usage. You can install above or below ground tanks.

Options for storing **runoff water**

Inter plot water harvesting: This method manages uncultivated areas in such a way that runoff is directed toward crops that need water

Inter row water harvesting: This method looks to store water in furrows or to plant crops in furrows specifically with the idea of catching runoff water

Water harvesting in farm ponds: With this method, a pond is located in the lower patches of a field in order to facilitate better storage and reduce seepage losses. The size of the pond will be determined based on the annual rainfall amount in your specific area, and the anticipated water needs.

Soil Conservation Methods

Contour Buffer Strips & Filter Strips
Mulching
Nutrient Management
Cover Crops
Heavy Use Area Protection

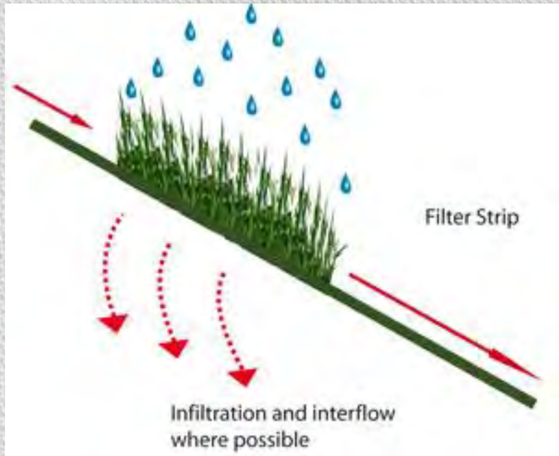
Contour Buffer Strips & Filter Strips

Filter Strips

•Also called grassed waterways

•Slow runoff allowing sediments, organic matter, and other pollutants that are being conveyed by the water to be removed by settling out in an area of herbaceous vegetation

•Allows water to infiltrate instead of being removed from the site



Contour Buffer Strips

Filter strips established around a hill or slope.

If working with a larger area of land that is losing soil via erosion, renovation may be needed to stop erosion processes yet still allow farming.

Mulching

This is the practice of applying plant residues or other suitable materials produced off site to the land surface.

- **Natural weed-prevention method**
- **Keeps soil moist and aerated**
- **Reduces airborne particulates**
- **Improves soil quality as it decomposes**
- **Reduces energy use associated with irrigation**
- **BUILDS ORGANIC MATTER!**

Use: ***grass clippings, leaves, pine needles, bark, wood chips, newspaper, and stone/gravel.***





Nutrient Management

Nutrient management is managing the amount, source, placement, and timing of plant nutrients and soil amendments. A soil test is the best way to determine your starting point. The most important thing to keep in mind is to ONLY add what you need. You don't want to waste time & money applying an excess of minerals to your soil.

Managing crop fertility inputs and other production practices for efficient crop growth and water quality protection. Put more simply:

Knowing what you have

Knowing what you need

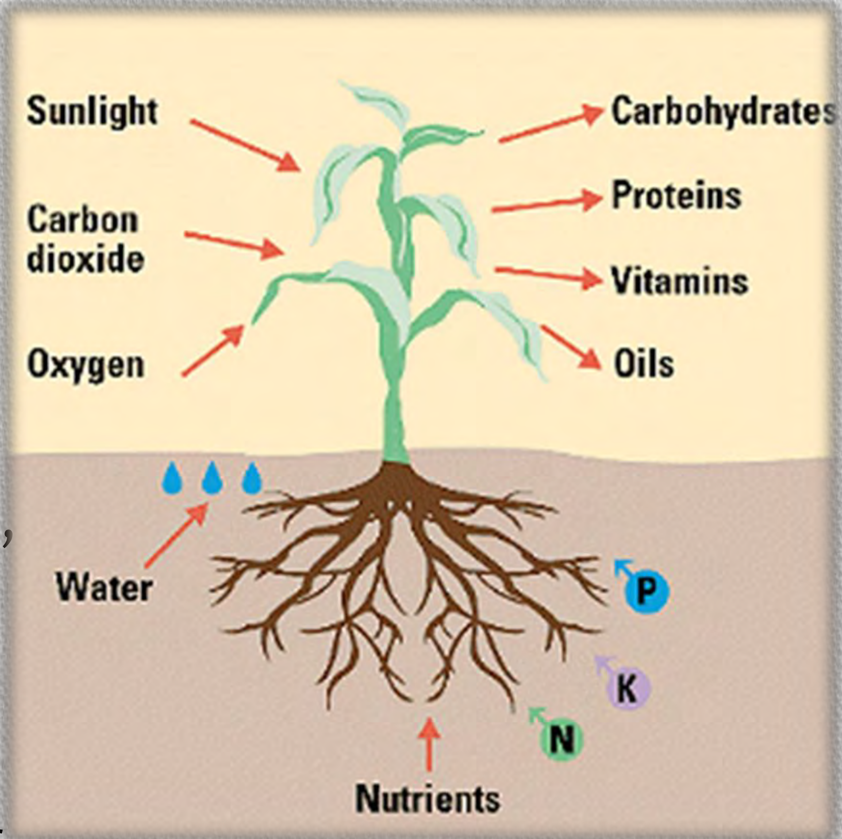
Managing it wisely

Documenting your management

**Definition credit to MSU's website*

Proper nutrient management lets you:

- Budget, supply, and conserve nutrients for plant production
- Minimize agricultural nonpoint source pollution of surface and groundwater resources
- Properly utilize manure or organic byproducts
- Protect air quality by reducing odors, nitrogen emissions, and the formation of atmospheric particulates
- Maintain and improve the physical, chemical, and biological condition of soil



These steps should be taken to practice effective nutrient management

- Obtain soil information for each field or unit
- Estimate yield potential for each field based on soil productivity and intended management
- Calculate plant nutrients required to reach the yield potential
- Determine plant-available nutrients in any livestock byproduct
- Estimate residual nutrient contributions from fertilizer or manures applied in previous seasons
- Apply animal manures and/or other forms of fertilizer using only what soil is deficient in
- Keep accurate records! (nutrient sources, application dates, rates, and methods)
- Make sure applications comply with any certifications

More info *Here*

mixing minerals

applying minerals

Cover Cropping

The use of cover crops is a way to improve and maintain soil health. They can include a wide variety of vegetation, including:

Grasses, *legumes*, *forbs*, and other plants that place beneficial nutrients into the soil.

Conservation Cropping Systems Initiative

Some goals when using cover crops include:

- Producing nitrogen fixation and reducing energy use
- Increasing active soil organic matter content
- Increasing biodiversity
- Managing soil moisture
- Minimizing soil compaction
- Reducing surface crusting
- Suppressing weeds
- Reducing soil erosion

Cover crop mix

Research before choosing which cover crops you want to use and when. The type of plants you'll want to grow can vary based on your objective. Some factors you'll want to consider include:

- management goals (why you need cover crop)
- season (when you want to plant)
- duration (how long it will stay until you need to plant the next crop)

white clover

cow peas and dutch clover

buckwheat

oats

See Cover Crop module for more details

Heavy Use Area Protection

- Stabilization of areas frequently and intensively used by people, animals, or vehicles is best achieved by establishing vegetative cover, surfacing with suitable materials, and/or installing needed structures.
- This conservation practice provides a stable surface that fights erosion.
- Example: Here is one method of installing heavy use area protection on a farm, specifically for the area surrounding a watering station.

Environmental Conservation Methods

Windbreaks & Hedgerows

Integrated Pest Management

Prescribed Burning

Forest Stand Improvement

Pollinator Habitats

Windbreak

Windbreaks (or shelterbelts) are single or multiple rows of trees or shrubs in linear configurations. They are implemented to reduce wind speeds which will slow soil erosion & protect plants.

Planting windbreaks involves planting several rows with shorter ones on the outside getting progressively larger to direct the wind away from things you'd like to protect such as fruit trees, livestock, driveways, or buildings.

Windbreaks can also:

- Alter the microenvironment for enhancing plant growth
- Manage snow deposition
- Provide shelter for structures, animals, and people
- Provide noise screens
- Improve air quality
- Improve irrigation efficiency
- Reduce energy use
- Produce edible nuts & fruits

chestnut

Include oaks & cherries to attract caterpillars that birds like; the birds in turn will eat the insect pests from your vegetables & fruit trees. Acorns & cherries are food for wildlife ***. Nut trees can be in the wind break and fruit trees downwind of it where the windbreak will provide winter protection.***

Hedgerows

Lower growing species than a windbreak. Edge species create barriers between farm elements.

hazelnuts

Purposes:

- Create a habitat (food, cover, and corridors) for wildlife
- Enhance pollen, nectar, and nesting habitat for pollinators
- Provide substrate for predaceous and beneficial insects as a component of integrated pest management
- Intercept airborne particulate matter
- Prove a screen and barrier to dust and noise
- Increase carbon storage in biomass and soils
- Create an integrated "living fence" with edible fruits/nuts such as hazelnuts
- Outline boundaries and contours

Avoid plant species that could be hosts for pests or diseases that threaten nearby crops; or could be poisonous if ingested by livestock.

Integrated Pest Management (IPM)

IPM involves a site-specific combination of pest prevention, pest avoidance, pest monitoring, and pest suppression strategies. The goal is to obtain the lowest possible level of pests and pest damage while avoiding practices that would cause hazards to people, property, or the environment.

Some practices include regularly inspecting and monitoring crops for damage, using mechanical trapping devices, natural predators (other insects), insect growth regulators, and mating disruption substances (pheromones).

This environmentally sensitive approach provides benefits such as:

- Prevention or mitigation of off-site or on-site pesticide risks to water quality from runoff, absorbed water, soil, air, plants, animals, and humans.
- Prevention or mitigation of on-site pesticide risks to pollinators and other beneficial species through direct contact.

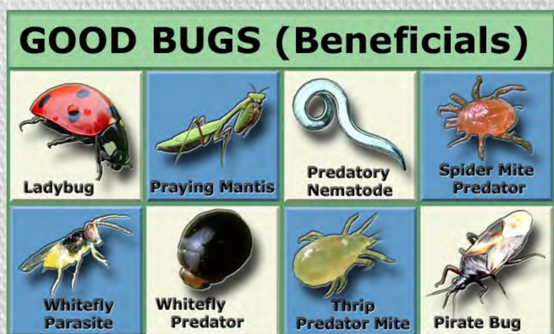
IPM implies the use of sprays as a last resort, and only on heavily infested trouble spots that are a small fraction of the total area. Of course in an organic operation only approved sprays (not pesticides) would be permitted.

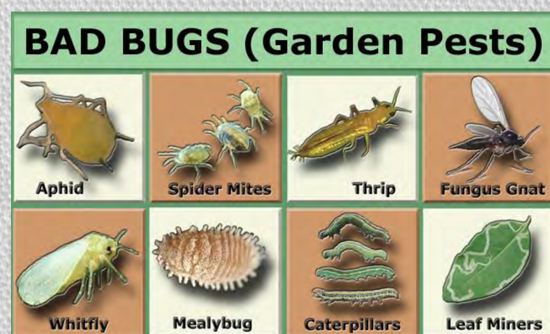
Harmful aphids

Good Bug or Bad Bug??

Monitor plants to know when action needs to be taken to prevent an unacceptable level of pests. It is important to target only harmful or disruptive insects. **Even organic sprays can kill the beneficial insects along with the harmful ones.**

Charts illustrating bad bugs and good ones





Lacewings know how to foil the ants

Syrphid flies , predatory wasps, and ladybugs all eat garden pests!

good bugs!

Juvenile praying mantis

Prescribed Burning

Controlled fire applied to a predetermined area can be effective as a conservation and restoration tool.

Prairie Burn

Prescribed burning uses:

- Control of undesirable vegetation
- Preparation of sites for planting
- Control of plant diseases
- Reduction of wildfire hazards
- Enhancement of seed production
- Restoration and maintenance of ecological sites

The burn leader should be trained in fire suppression and be in contact with local fire departments. Agricultural land is often exempted from local restrictions on burning.

U.S Fish and Wildlife Service: Detailed information on their website provides information on prescribed burning

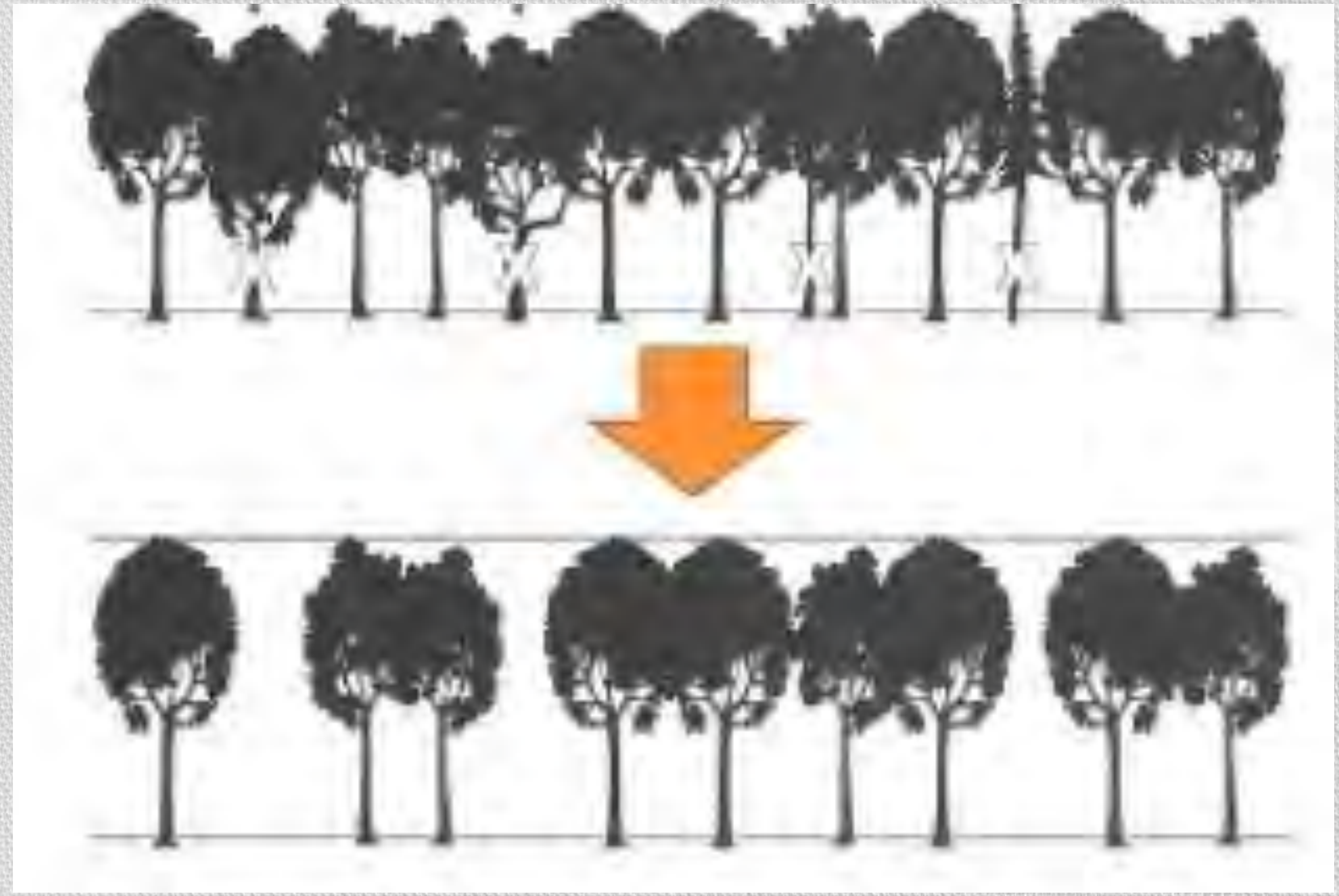
Forest Stand Improvement

Forest Stand improvement includes manipulation of species composition, stand structure, and stocking by cutting or killing selected trees and surrounding vegetation.

Possible benefits:

- Increase the quantity and quality of forest products by manipulating stand density and structure
- Develop renewable energy systems
- Initiate forest stand regeneration
- Reduce wildlife hazards
- Alter water yield
- Increase carbon storage in selected trees
- Achieve and maintain a desired native understory plant community for **special forest products** or grazing/browsing by livestock.

Forest Stand Improvement



**Undesirable trees are removed to realize the full benefits in this conservation method.*

Precise management should be used when grazing livestock to avoid damage!

Pollinator Habitats

Pollination is critical to farming. North America has around 4,000 native bee species and countless other pollinators including wasps, butterflies, moths, flies, beetles, hummingbirds, and bats as well as the European honey bee. They pollinate our plants and in the case of honeybees, give us delicious (and marketable!)

honey. (See Beekeeping module)

Pollinator Habitats

As natural habitats around the globe are threatened, it is especially important that farmers create pollinator habitats whenever possible.

Considerations:

1. Field layout: pollinator strips need to be near crops.

2. Invasive potential: research new plantings to be careful you're not introducing potentially invasive species (see Grazing module for more info). Some species, if properly controlled, can have many uses in addition to being a source of nectar & pollen, eg black locust.

Pollinator Habitats

Two thirds of all native bee species nest underground. Ground disturbance should be minimized as much as possible to protect nests.

pollinator conservation

Avoid excessive tillage, plastic mulch use, and soil fumigation.

Nature's amazing food chain: bees serve as food for larger animals like birds and amphibians, and of course, the fruits that come from the pollinated plants feed larger animals and us.

Spotlight on Permaculture: Restoration Agriculture

The term Permaculture can be described as a method of thinking which conserves resources and applies knowledge of the biological system in a holistic way. Restoration Agriculture interconnects conservation practices and works them into designs that can sustainably grow perennial food crops on land at many different scales. Alley cropping allows alternation of tree crops and pastures or crops. Nature is the model and in the Midwest the model ecosystems include oak savannah, prairie, and woodland. "An oak savannah mimic will produce more than twice the number of edible human calories per acre as an average acre of corn" * plus reduce the amount of waste generated, use less energy, be prepared for and better respond to change, and enjoy more profit for the farm. Silvopasture methods combine livestock pastures & trees. Integration of these practices will protect current resources and ensure that they are around for future generations.

*as quoted in "Restoration Agriculture" by Mark Shepard

References

Natural Resources Conservation Services Website

http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/cp/

Weed the Soil Not the Crop : A Whole Farm Approach to Weed Management, by Anne & Eric Nordell

Restoration Agriculture by Mark Shepard

Bringing Nature Home by Douglas Tallamy

Assessment and Review

1. What is the intention of conservation practices?
2. Name and describe two effective conservation practices
3. Recall three materials that can be used for mulching
4. Describe two benefits of nutrient management.