

Ag Intern Orientation & Training

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OSHA FactSheet

Farm Safety

Contrary to the popular image of fresh air and peaceful surroundings, a farm is not a hazard-free work setting. Every year, thousands of farm workers are injured and hundreds more die in farming accidents. According to the National Safety Council, agriculture is the most hazardous industry in the nation.

Health and Safety Hazards on Farms

Farm workers—including farm families and migrant workers—are exposed to hazards such as the following:

- Chemicals/Pesticides
- Cold
- Dust
- Electricity
- Grain bins
- Hand tools
- Highway traffic
- Lifting
- Livestock handling
- Machinery/Equipment
- Manure pits
- Mud
- Noise
- Ponds
- Silos
- Slips/Trips/Falls
- Sun/Heat
- Toxic gases
- Tractors
- Wells

High Risk Factors on Farms

The following factors may increase risk of injury or illness for farm workers:

- **Age** – Injury rates are highest among children age 15 and under and adults over 65.
- **Equipment and Machinery** – Most farm accidents and fatalities involve machinery. Proper machine guarding and doing equipment maintenance according to manufacturers' recommendations can help prevent accidents.
- **Protective Equipment** – Using protective equipment, such as seat belts on tractors, and personal protective equipment (such as safety

gloves, coveralls, boots, hats, aprons, goggles, face shields) could significantly reduce farming injuries.

- **Medical Care** – Hospitals and emergency medical care are typically not readily accessible in rural areas near farms.

How You Can Improve Farm Safety

You can start by increasing your awareness of farming hazards and making a conscious effort to prepare for emergency situations including fires, vehicle accidents, electrical shocks from equipment and wires, and chemical exposures. Be especially alert to hazards that may affect children and the elderly. Minimize hazards by carefully selecting the products you buy to ensure that you provide good tools and equipment. Always use seat belts when operating tractors, and establish and maintain good housekeeping practices. Here are some other steps you can take to reduce illnesses and injuries on the farm:

- Read and follow instructions in equipment operator's manuals and on product labels.
- Inspect equipment routinely for problems that may cause accidents.
- Discuss safety hazards and emergency procedures with your workers.
- Install approved rollover protective structures, protective enclosures, or protective frames on tractors.
- Make sure that guards on farm equipment are replaced after maintenance.
- Review and follow instructions in material safety data sheets (MSDSs) and on labels that come with chemical products and communicate information on these hazards to your workers.

- Take precautions to prevent entrapment and suffocation caused by unstable surfaces of grain storage bins, silos, or hoppers. Never “walk the grain.”
- Be aware that methane gas, carbon dioxide, ammonia, and hydrogen sulfide can form in unventilated grain silos and manure pits and can suffocate or poison workers or explode.
- Take advantage of safety equipment, such as bypass starter covers, power take-off master shields, and slow-moving vehicle emblems.

The Benefits of Improved Safety and Health Practices

Better safety and health practices reduce worker fatalities, injuries, and illnesses as well as associated costs such as workers' compensation insurance premiums, lost production, and medical expenses. A safer and more healthful workplace improves morale and productivity.

Additional Information on Safety and Health

For more information about farm safety, visit OSHA's website at www.osha.gov/SLTC/agriculturalopera

tions, the National Safety Council at www.nsc.org/farmsafe/facts.htm, the Environmental Protection Agency at www.epa.gov/pesticides/safety/workers/workers.htm, and the Centers for Disease Control at www.cdc.gov/nasd/menu/topic/topic.html. In addition, OSHA has a variety of materials and tools available elsewhere on its website at www.osha.gov.

OSHA Publications

OSHA has an extensive publications program. For a listing of free or sales items, visit OSHA's website at www.osha.gov/pls/publications/pubindex.list or contact the OSHA Publications Office, U.S. Department of Labor, 200 Constitution Avenue, NW, N-3101, Washington, DC 20210. Telephone (202) 693-1888 or fax to (202) 693-2498.

Contacting OSHA

To report an emergency, file a complaint or seek OSHA advice, assistance or products, call (800) 321-OSHA or contact your nearest OSHA regional or area office.

This is one in a series of informational fact sheets highlighting OSHA programs, policies or standards. It does not impose any new compliance requirements. For a comprehensive list of compliance requirements of OSHA standards or regulations, refer to Title 29 of the Code of Federal Regulations. This information will be made available to sensory impaired individuals upon request. The voice phone is (202) 693-1999; teletypewriter (TTY) number: (877) 889-5627.

For more complete information:



U.S. Department of Labor

www.osha.gov

(800) 321-OSHA

Heat Kills

Heat illness includes **heat cramps, fainting, heat exhaustion, and heatstroke.**

Workers have died or suffered serious health problems from these conditions.

Heat illness can be prevented.



Know the symptoms of heat illness

Watch for symptoms in yourself and your coworkers. *If you feel any symptoms, tell your coworkers and supervisor immediately because you may need medical help. Know who to talk to and how to get help before you start each workday.*



Early symptoms

Fatigue
Heavy sweating
Headache
Cramps
Dizziness
High pulse rate
Nausea/vomiting



Life-threatening symptoms

High body temperature
Red, hot, dry skin
Confusion
Convulsions
Fainting



Preventing Heat Illness

Tell your supervisor if you are new to working in the heat or have had heat illness before.

Stay alert to the weather During a heat wave you are at greater risk of getting sick. You need to watch yourself and coworkers more closely, and may need to drink more water, take more breaks, and use other measures.



Drink enough cool, fresh water

Drink at least one 8-ounce cup (3 cones) every 15 minutes during your entire work shift. *Do not wait until you are thirsty to drink water.*

Do not drink alcohol. Avoid coffee. Choose water over soft drinks.



Take rest breaks in the shade to cool down.

Wear proper clothing Loose fitting, light-weight and light-colored cotton clothes, a wide-brimmed hat or cap, and a bandana.

Talk to your doctor if you have illnesses like diabetes, are taking medicines or are on a low salt diet.

Know Your Rights

If you work outdoors, by law, your employer must provide you:

- Enough cool, fresh drinking water throughout the day.
- Access to shade or an equally cool spot for at least 5 minutes at a time.
- Training on how to prevent heat illness and how to call for emergency services.




For more information call the worker hotline at 1-866-924-9757

California Department of Industrial Relations



Illustrations by Kate Oliver and Adria Wells



Las enfermedades causadas por el calor incluyen los calambres musculares, el desmayo, el agotamiento debido al calor y la insolación.

Los trabajadores han muerto o sufrido problemas graves de salud debido a éstas condiciones.

Las enfermedades causadas por el calor pueden ser prevenidas.



Conozca los síntomas de las enfermedades causadas por el calor. Esté alerta a estos síntomas en sí mismo y en sus compañeros de trabajo. Si usted siente cualquiera de estos síntomas, informe de inmediato a sus compañeros de trabajo y supervisor porque puede ser que usted necesite atención médica. Antes del comienzo de cada día de trabajo sepa con quien debe hablar y cómo obtener ayuda en caso de emergencia.



Síntomas iniciales

Fatiga
Sudor abundante
Dolor de cabeza
Calambres
Mareos, Pulso alto
Nausea/vómito

**BUSCA
ATENCIÓN
MÉDICA**



Síntomas de emergencia

Temperatura de cuerpo alta
Piel seca, enrojecida y caliente
Confusión mental
Convulsiones, Desmayo

Informe a su supervisor si usted está comenzando a trabajar en el calor o si ya ha sufrido de las enfermedades causadas por el calor.

Esté alerta al tiempo. Durante la ola de calor usted está a mayor riesgo de enfermarse. Usted necesita estar muy atento a sí mismo y a sus compañeros de trabajo, necesita beber más agua, tomar más descansos y usar otras medidas preventivas.



Tome suficiente agua fresca

Tome por lo menos una taza de 8 onzas (3 conos) cada 15 minutos durante toda la jornada de trabajo. *No espere hasta sentir con sed para tomar agua.*

No tome bebidas alcohólicas. Evite el café. Elija agua en lugar de sodas.



Descanse en la sombra para tomar alivio del calor.

Use ropa apropiada. Ropa de algodón liviana, suelta y de color claro, gorra o sombrero de ala ancha y un pañuelo.

Consulte con su doctor si usted tiene enfermedad como la diabetes, está tomando medicinas o está en una dieta baja de sal.

Si trabaja al aire libre, por ley, su patrón debe proveer:

- Suficiente agua fresca para beber durante todo el día
- Acceso a la sombra o un lugar igualmente fresco por un periodo mínimo de cinco minutos para que pueda refrescarse.
- Entrenamiento sobre cómo prevenir las enfermedades causadas por el calor y cómo llamar a los servicios de emergencia.



Para más información llame gratis al

1-866-924-9757

(Oprima el "1" para escuchar los mensajes en español)

**Departamento de Relaciones
Laborales de California**



Safety tips for workers during harvest

Staying safe during harvest

1. Recognize limitations: don't carry heavy loads, don't stretch and twist excessively, learn how to bend correctly: from the knees, not the back, rest when tired.
2. Avoid heat stress. Drink plenty of water while working -- 5 to 7 ounces of water every 15 to 20 minutes. Wear light colored and lightweight, loosely woven clothing.
3. Protect skin from sun exposure, including broad-brimmed hat, long sleeves, and checking your skin for unusual, persistent blemishes.
4. Be aware of nearby machinery.
5. Exercise sufficient caution when working with machinery; beware of unshielded, moving equipment parts.
6. If your hearing is not what it used to be, consider getting a hearing aid and make sure you remain visually alert to nearby activity.
7. Use all of the safety devices, such as the rollover bar on most tractors and a safety belt. If you use older tractor models, have these items installed.

Common causes of cotton harvest injuries

1. Serious or fatal injuries occur when tractors overturn, especially when driving at the edges of canals and ditches, and when exiting or entering the field. Some tips for tractor drivers to avoid accidents include:
 - a. pay attention to terrain conditions and features
 - b. drive slowly
 - c. make sure that lights are functioning at night
 - d. have a ROP (rollover protection)
 - e. always start tractor from operator platform
 - f. take special care when freeing equipment that is stuck in the mud and when hitching trailers or other equipment to the tractor.
2. A common type of serious or fatal accident, in cotton and other field crop harvest operations, involves trying to unclog the equipment while the equipment is still running. Turn off equipment before trying to unclog it and make sure it has stopped moving!!!! Equipment parts can and should be rotated by hand to help with the unclogging process.
3. Workers sometimes get caught and crushed between two pieces of moving power equipment, for example during towing.
 - a. No one should ever be allowed between two pieces of moving equipment.
 - b. Always check to make sure no one is in the way before putting equipment in motion.
4. Fires are a significant risk during harvest because of the flammable cotton lint and other plant debris that accumulates near the hot engine and other machinery parts.
 - a. Clean out lint frequently do not allow it to accumulate.
 - b. Check exhaust pipes and muffler routinely for leaks.
 - c. Mount a multipurpose, dry-chemical type fire extinguisher on the harvester and train all workers to use it.

Avoiding falls from ladders during harvest

1. Check your ladder before you use it; make sure it is in good condition. Look for missing or broken steps and rails, and missing rubber pads added to steps to prevent slips. Make sure there is no slippery oil or grease on rungs.
2. When climbing, face the ladder and don't skip steps.

3. Never climb above the third rung from the top.
4. Do not try to reach too far, move the ladder.
5. Use the side rails of the ladder, not the rungs, for balance.
6. Start picking from the top, so that as your bag gets fuller and heavier, you are closer to the ground, not higher up.
7. Delay harvest during high wind.
8. Pay attention to the presence of electrical wiring in the orchard; if present, avoid contact with these wires.

Courtesy of The University of California Farm Safety Program

Soils for Gardeners



*Edd Russell
USDA-NRCS
1/21/2005*

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I. Introduction

a. Importance of Soil

1. (Discuss uses of soil)

b. What is Soil?

1. Different concepts → Different definitions

- a) Edaphological (in relation to plant growth)

A mixture of mineral and organic material that is capable of supporting plant life.

- b) Engineering

Mixture of mineral material (sands, gravels and fines) used as a base for construction.

- c) Pedological (sees soil as a distinct entity)

The unconsolidated mineral or organic material on the surface of the earth that has been subjected to and shows effects of genetic and environmental factors of: **climate** (including water and temperature effects), and **macro- and micro-organisms**, conditioned by **relief**, acting on **parent material** over a period of **time**. Geosphere-Biosphere-Atmosphere interface.

"Soil Science isn't rocket science--it's harder." -- Kit Paris

Some of the disciplines involved in soil science: chemistry, biology, botany, zoology, geology, geomorphology, climatology, hydrology, entomology, engineering, mineralogy, agronomy, forestry, and physics

c. Functions of Soil?

1. Support growth of higher plants
2. Primary factor controlling fate of water in hydrologic system
3. Nature's recycling system
4. Habitat for organisms
5. Engineering Medium

II. How soil is made

a. Soil Forming Factors

At one time it was felt that soils were static. In the late 1800's, Russian soil scientists introduced the concept that soils are dynamic – that they developed to the point where they are now and that they are evolving into what they will be. They came up with 5 soil forming factors that influence how soils turn out the way they do. The idea is that if all five of the soil forming factors are the same, then the soil will be the same. The technical term used for soil formation is **pedogenesis**.

Weathering is the term used to refer to the breakdown of rock into smaller and smaller pieces. Two types of weathering are recognized, chemical and mechanical (physical). Mechanical weathering has to do with the breakdown of rock due to physical factors such as temperature fluctuations and freeze/thaw cycles of water. An example would be quartz breaking down to fine sand size particles. (Since quartz is resistant to chemical weathering, it won't get much smaller than this.)

Chemical weathering refers to the breakdown of rock due to chemical reactions. For example, limestone (CaCO_3) and gypsum (CaSO_4) dissolve in water and become smaller and smaller. Micas can lose potassium ions and become vermiculite. Vermiculite, in turn, can lose more potassium and become smectite. Feldspars lose potassium and become kaolinite. In these cases, rock weathers to a microscopic or even elemental state.

1. Time How long the soil has been forming
2. Parent Material e.g., rock, alluvium; inherent fertility
3. Biotic Factors plants, animals, microorganisms
4. Topography slope position, aspect, shape and amount
5. Climate temperature, moisture, seasonal distribution

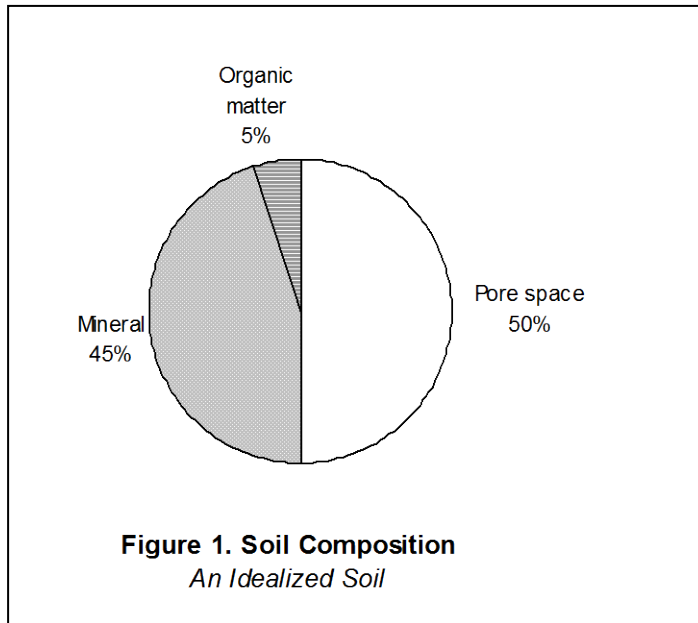
b. Soil Profiles and Soil Development

1. Soil horizons
Soils consist of one or more distinct layers called **horizons**. These layers are referred to as O, A, E, B, C and R depending on their position and nature
 - O Layers dominated by organic material. Usually not present under warm-dry conditions.
 - A The mineral soil horizon which is usually at the surface or below an O horizon. It usually has more organic carbon than underlying layers. Sometimes this layer is missing or truncated due to erosion or removal. Also, all surfaces resulting from plowing, pasturing or similar disturbances are referred to as A horizons.
 - E Horizon characterized by eluviation (removal of materials such as silicate clay, iron or aluminum), if distinct from the A horizon. Frequently not present. Usually more pale colored than the A horizon.
 - B A horizon, formed below an A, E, or O horizon, which is dominated by obliteration of all or much of the original rock structure and which shows evidence of soil formation such as illuvial (moved down from an above horizon) concentration of silicate clay, iron, aluminum, humus, carbonates, gypsum or silica; development of soil color or structure; or brittleness, etc.
 - C Horizons or layers, excluding hard bedrock, that are little affected by pedogenic (soil forming) processes and that lack properties of O, A, E or B horizons.
 - R Hard bedrock
2. Soil horization

c. What is in soil?

(See figure 1, page 2)

1. Mineral – 40-50 percent
 - a) Gravel, Cobbles, Stones, Boulders
 - b) Sand (0.05 - 2.00 mm)
 - c) Silt (0.002 - 0.05 mm)
 - d) Clay (< 0.002 mm)
2. Biological – 0-10
 - a) Flora and Fauna
 - b) Live and Dead (Organic matter)
 - c) Macroscopic and Microscopic
3. Pore space – 50 percent
Pore space consists of the “empty” spaces in the soil. While this might seem to make the pore space unimportant, in reality it is a **very important** part of the soil. Pore space might be filled with one of two things:
 - a) Air
 - b) Water



III. Soil Properties

a. Texture

1. Soil Separates (mineral part of soil)
 - a) Sand-- gritty
 - b) Silt-- floury when dry, greasy when wet
 - c) Clay
 - (1) morphology
 - Most clay minerals consist of microscopic layers. These are called **phyllosilicate** minerals. (phyllo- is from Greek for leaf, as in phyllo dough used to make baklava.) See diagrams in Appendices 2 & 3.
 - Different types of clay have different kinds of layers and different properties
 - Some clay minerals are amorphous—without shape. Common in humid temperate woodlands (Spodosols) and volcanic soils (Andisols)
 - (2) properties of clays
 - sticky (adhesion-sticks to other things) (target demo)
 - plastic (cohesion-sticks to itself) (ribbon demo)
 - shrink-swell (slinky demo)
 - large surface area, due to layers and to size
 - Cation Exchange Capacity (CEC)
clay has net negative charge, attracts cations (positive ions; ions are broken molecules. Certain ions serve as plant nutrients)
2. Texture Triangle
 - a) There is a diagram in Appendix 5 which shows how the 12 soil textures are distinguished on the basis of the amount of sand, silt and clay. This diagram is called the **texture triangle**. There is also a chart for determining the soil texture by the field method in Appendix 4.

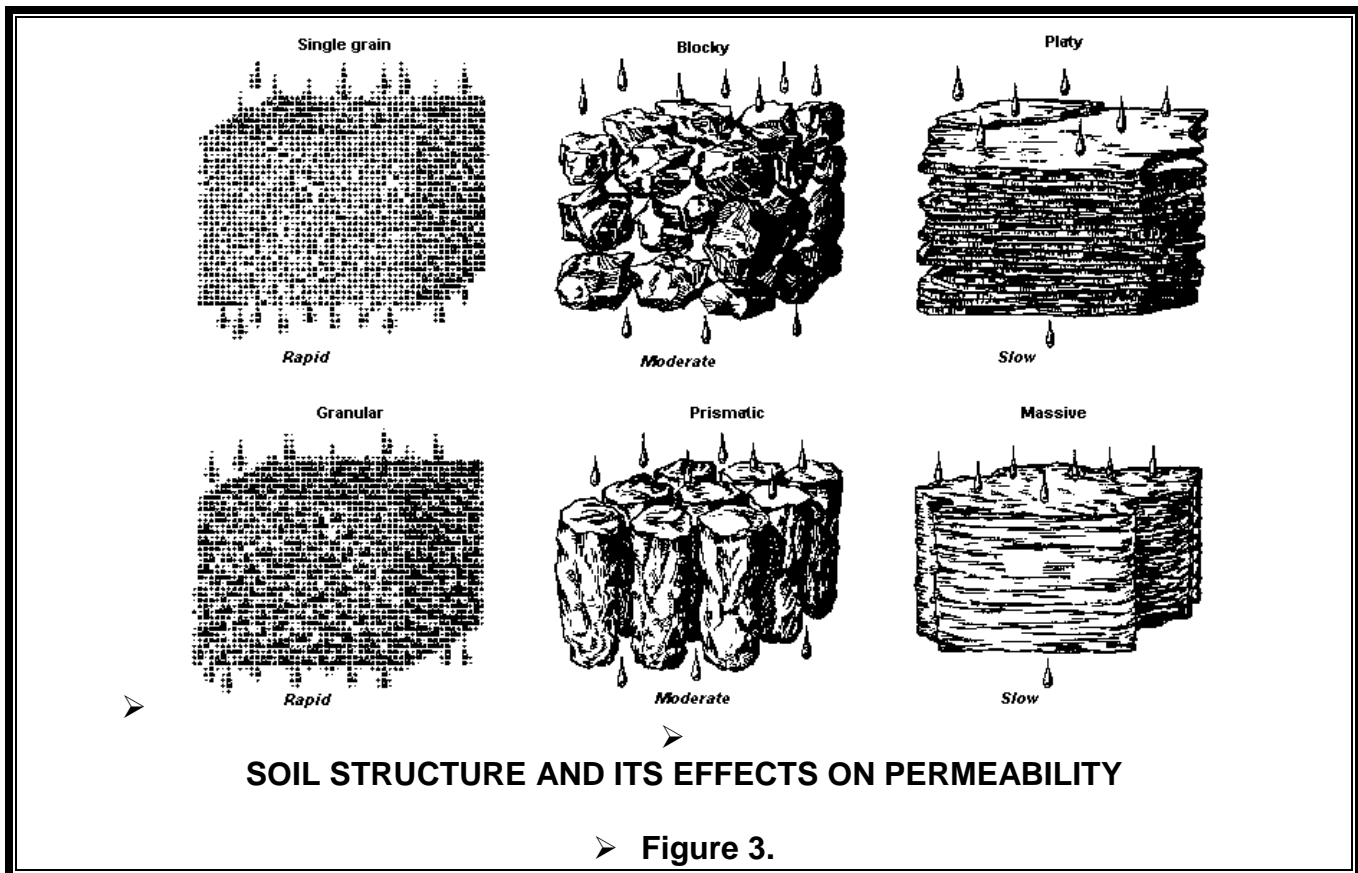
b. Structure

1. What is it
 - a) Arrangement of soil particles into aggregates
 - b) Natural vs. man-made (peds vs. clods)
 - c) Types (shape) (See Figure 3)
 - (1) granular
 - (2) blocky (angular and sub-angular)
 - (3) platy
 - (4) columnar and prismatic
 - (5) single grain (non-structure)
 - (6) massive (non-structure)-
 - d) Size: very fine, fine, medium, coarse, very coarse, thick, thin

Size class	Platy	Columnar/Prismatic	Blocky	Granular
	mm	mm	mm	mm
Very fine (thin)	<1	<10	<5	<1
Fine (thin)	1-2	10-20	5-10	1-2
Medium	2-5	20-50	10-20	2-5
Coarse (thick)	5-10	50-100	20-50	5-10
Very coarse(thick)	>10	>100	>50	>10

Table 1
Size Classes of Soil Structural Units
Thin and thick, rather than fine and coarse, are used for platy structures

- e) Grade
Weak: Peds barely observable in place, difficult to distinguish from massive or single grain.
Moderate: Peds well formed and evident in undisturbed soil
Strong: Peds distinct in undisturbed soil. Peds have distinctive surface features.
- f) Compound structure
 (1) One structure beside another
 (2) One structure within another ("parts to...")
- g) Persistence upon wetting and drying—"Aggregate stability"
2. What causes structure?
 a) biological factors/organic matter
 - bacterial exudates
 - root activity and exudates
 - macrofauna activity and waste
 b) clay (type and amount)
 c) calcium and sodium effects
 d) climate (wet/dry, freeze/thaw)



c. Pores

1. What are they and why are they important?
 Pores are the "holes" or voids in the soils. They are important because air in water move through and are stored in pores. Without air, roots cannot live nor can most microbes that are essential to the proper functioning of a healthy soil.

2. Types of pores
 - a) Three types of pores are generally recognized:
 - b) interstitial pores: spaces between mineral grains and peds
 - c) tubular pores: pores made by root or animal activity that are or were at one time continuous
 - d) vesicular pores: bubble shaped pores
3. Sizes of pores
 - a) Two basic size classes of pores are recognized, though there is not a particular size limit between them.
 - b) macropores: allow free movement of air and water
 - c) micropores: air movement is greatly impeded, water movement is restricted to capillary flow.

d. Bulk Density

1. What is it

The bulk density of the soil (or of anything else) is the (oven dry) weight of a given volume of soil divided by the volume. It is expressed in grams per cubic centimeter. The formula is usually written like this:

$$Db = M_s / V_t$$

Where

Db=bulk density
 M_s=mass of solids
 V_t=total volume

Soil bulk density values range from 0.5 to 3.0 but most values are between 0.8 and 1.8. Anything denser than about 1.8 is root limiting.

Bulk density is usually determined by coating a mass of soil with a thin layer of plastic; weighing the soil, correcting for moisture content; then determining the volume of that soil by water displacement.

The bulk density of the soil is a reflection of the amount of pore space in the soil. Other factors affecting the bulk density are the types of minerals present (some are heavier than others are), the texture (clays are lighter than silts and sands) and the amount of organic matter (organic matter has a really low bulk density compared to mineral grains).

2. Importance

Compacted soils have higher bulk densities than non-compacted soils.

e. Organic Matter

Organic matter consists of dead plant parts and animal and microbial waste products in various stages of decomposition. Eventually, these things break down into humus, which is relatively stable in the soil.

1. Importance of organic matter

Though organic matter makes up a minor part of the soil, it has a very strong impact on it.

- a) Structure

Organic matter acts like glue which helps hold soil aggregates together. This will even hold upon wetting.

- b) Available Water Capacity (AWC)

Organic matter helps bind water to the soil to keep it from being lost through percolation. This is especially important in sandy soils

- c) Cation Exchange Capacity (CEC)

While the highest CEC you will find in a clay is 160 meq/100g (cmol/kg), humus has a CEC of 100 to 300 meq/100g (cmol/kg) or more.

2. Relationship to climate

You cannot add large amount of organic matter to the soil and expect it to persist. There is a maximum equilibrium amount any given soil can hold. This amount is inversely proportional to soil temperature and moisture. That is to say, wetter and colder soils can maintain higher equilibrium amounts of organic matter. Anything added beyond that amount will breakdown to carbon dioxide and water. The equilibrium amount can be raised, to some degree by additions of organic matter, such as in organic gardening situations, but even then it will only go so high. Tropical soils, for example, tend to be nutrient and organic matter poor- the nutrient pool tends to be stored in the above ground biomass (leaves and branches). The muskeg areas of northern Canada, however, contain large amounts of organic matter.

A new practice related to this is being employed to reduce greenhouse gas emissions. Carbon sequestration is the practice of burying organic matter deep in the soil to maximize the amount of organic carbon it contains. To the extent that the soil can hold the organic carbon in equilibrium, it will reduce emissions of CO₂ from the soil.

f. Color

1. How it is measured

Munsell Color Notation (show color book)

2. Significance of—indicator of—

a) Drainage and Wetness (Redoximorphic features)

Greenish, bluish and gray colors in the soil indicate wetness. These colors may occur as the dominant color (matrix) or in patches (mottles). The colors are caused by the reduction of iron by bacteria in anaerobic conditions. (The bacteria get the electrons they need for energy from iron rather than from oxygen.) These colors will persist even if the area is drained, so they serve as indicators, not proof.

Bright colors (reds and yellows), on the other hand, indicate well-drained soils. You don't want to have *free water* (water in excess of the available water capacity) within the rooting depth of your plants during the growing season. It is possible for a soil with bright colors to still have wetness problems if the groundwater is moving fast enough and if it has sufficient oxygen or if it is too cold for biological activity.

b) Organic Matter

Dark colors in the soil usually indicate organic matter. They may also indicate wetness (remember, wetter soils can accumulate more organic matter). Sometimes, the color may be derived from the parent material. This is often the case in soils derived from basic (dark colored) igneous rock.

g. 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 may limit depth are:

1. bedrock
2. densely compacted material (tillage pan)
3. natural hardpans (soil cemented by iron, lime, gypsum, silica, etc.) (Show example)
4. strongly contrasting textures (pot effect)
5. water tables

h. Soil Temperature

Soil temperature is important to gardeners, especially when it comes to spring planting. Many seeds need a certain minimum temperature before they will germinate.

1. Factors influencing soil temperature

- a) Local climate—soil temperature is highly correlated to air temperature

- b) Slope steepness and aspect—in the Northern Hemisphere, north-facing aspects tend to be cooler than south facing aspects. The effect is more pronounced with steeper slopes and lower relative humidity
 - c) Topography—topography influences microclimates. For example, cool air flows down from mountaintops along drainages and settles in low parts of valleys. Soil and air temperature in these drainages and low areas may be lower than the elevated areas adjacent to them. This is readily apparent in the "citrus belt" in the San Joaquin Valley.
 - d) Cover—plants shade the soil, reducing the temperature. In addition, growing plants cool the temperature through transpiration.
 - e) Soil Color—darker colored soils absorb heat more readily than lighted colored soils.
2. Soil temperature influences on soil properties
 - a) Biological activity: ↑temperature→↑biological activity. Below about 40°F there is little biological activity.
 - b) Organic matter accumulation: ↑temperature→↓organic matter accumulation.
 - c) Weathering of parent materials: fluctuating temperatures help break down mineral grains; warmer temperatures increase chemical weathering.
 - d) Nutrient availability: Many nutrients are unavailable or poorly available at low temperatures, especially phosphorus. (This is primarily related to biological activity.)

i. Drainage

Soil drainage or drainage classes is a way of expressing the frequency and duration of periods in which the soil is saturated (has free water or water in excess of field capacity). Excess free water in the root zone can kill plants or keep them from getting established. The U.S. Department of Agriculture recognizes seven natural drainage classes:

1. Excessively drained.
Water is removed very rapidly. The occurrence of internal free water commonly is very rare or very deep. The soils are commonly coarse-textured and have very high hydraulic conductivity or are very shallow. These soils tend to be droughty.
2. Somewhat excessively drained.
Water is removed from the soil rapidly. Internal free water occurrence commonly is very rare or very deep. The soils are commonly coarse-textured and have high saturated hydraulic conductivity or are very shallow.
3. Well drained.
Water is removed from the soil readily but not rapidly. Internal free water occurrence commonly is deep or very deep; annual duration is not specified. Water is available to plants throughout most of the growing season in humid regions. Wetness does not inhibit growth of roots for significant periods during most growing seasons. The soils are mainly free of the deep to redoximorphic features that are related to wetness.
4. Moderately well drained.
Water is removed from the soil somewhat slowly during some periods of the year. Internal free water occurrence commonly is moderately deep and transitory through permanent. The soils are wet for only a short time within the rooting depth during the growing season, but long enough that most mesophytic crops are affected. They commonly have a moderately low or lower saturated hydraulic conductivity in a layer within the upper 1 m, periodically receive high rainfall, or both.
5. Somewhat poorly drained.
Water is removed slowly so that the soil is wet at a shallow depth for significant periods during the growing season. The occurrence of internal free water commonly is shallow to moderately deep and transitory to permanent. Wetness markedly restricts the growth of mesophytic crops, unless artificial drainage is provided. The soils commonly have one or

more of the following characteristics: low or very low saturated hydraulic conductivity, a high water table, additional water from seepage, or nearly continuous rainfall.

6. Poorly drained.

Water is removed so slowly that the soil is wet at shallow depths periodically during the growing season or remains wet for long periods. The occurrence of internal free water is shallow or very shallow and common or persistent. Free water is commonly at or near the surface long enough during the growing season so that most mesophytic crops cannot be grown, unless the soil is artificially drained. The soil, however, is not continuously wet directly below plow-depth. Free water at shallow depth is usually present. This water table is commonly the result of low or very low saturated hydraulic conductivity or nearly continuous rainfall, or of a combination of these.

7. Very poorly drained.

Water is removed from the soil so slowly that free water remains at or very near the ground surface during much of the growing season. The occurrence of internal free water is very shallow and persistent or permanent. Unless the soil is artificially drained, most mesophytic crops cannot be grown. The soils are commonly level or depressed and frequently ponded. If rainfall is high or nearly continuous, slope gradients may be greater.

j. Odor

1. Indicator of wetness

When soils are waterlogged, bacteria will get their oxygen from sulfur. This will release hydrogen sulfide gas. This accounts for the sulfur smell prevalent around saltmarshes.

k. Permeability

1. Rate at which water moves through the soil

Permeability is the rate at which water moves down through the soil. It is usually measured in inches per hour. **Infiltration** is the rate at which water enters the soil. It is similar to permeability, except that it also takes into account surface conditions.

Permeability and infiltration rates affect the rate at which you can safely apply water to the field. Applying water faster than the permeability and infiltration rates can lead to sealing of the soil surface, which further decreases infiltration rates; it can also cause ponding, which increases the possibility of diseases; and it can lead to runoff, which causes erosion and possible fertilizer loss.

The permeability of a soil can be no faster than the permeability of the slowest layer. For example, sandy loam has a permeability of 2.0 to 6.0 inches per hour. Sandy clay loam has a permeability of 0.2 to 0.6 inches per hour. A soil that has a sandy loam surface over a sandy clay loam subsoil will have a permeability of 0.2 to 0.6 inches per hour.

2. Measurement (in./hr.)

Permeability is normally measured in inches per hour. A newer expression you will see is Saturated Hydraulic Conductivity (K_{sat}). It is measured in $\mu\text{m}/\text{sec}$ or cm/hr .

3. Properties influencing permeability

a) Texture

Soil texture is usually the dominant soil property affecting infiltration. Soils that are high in clay content tend to have a slower permeability. Soils that are high in sand content tend to have a faster permeability. (See table 2)

Texture Class	Texture	Permeability Rate (in./hr.)	Permeability Class (in./hr.)
Coarse	gravel coarse sand	More than 20.00	very rapid
	sand loamy sand	6.00-20.00	rapid
Moderately Coarse	coarse sandy loam sandy loam fine sandy loam	2.00-6.00	moderately rapid
Medium	very fine sandy loam Loam silt loam silt	0.60-2.00	moderate
Moderately fine	clay loam sandy clay loam silty clay loam	0.20-0.60	moderately slow
Fine	sandy clay silty clay clay (<60%)	0.06-0.20	slow
Very fine	clay (>60%) claypan	Less than 0.06	very slow

Table 2.
Soil Permeability Chart

These are normal values for non-compacted soils, such as in grassland situations

Soil texture not only affects how fast water moves through the soil, it also affects the pattern by which water moves through the soil. Water will move almost straight down through a sandy soil, whereas it will have more lateral movement in a heavier soil (one with more clay). (See fig. 5)

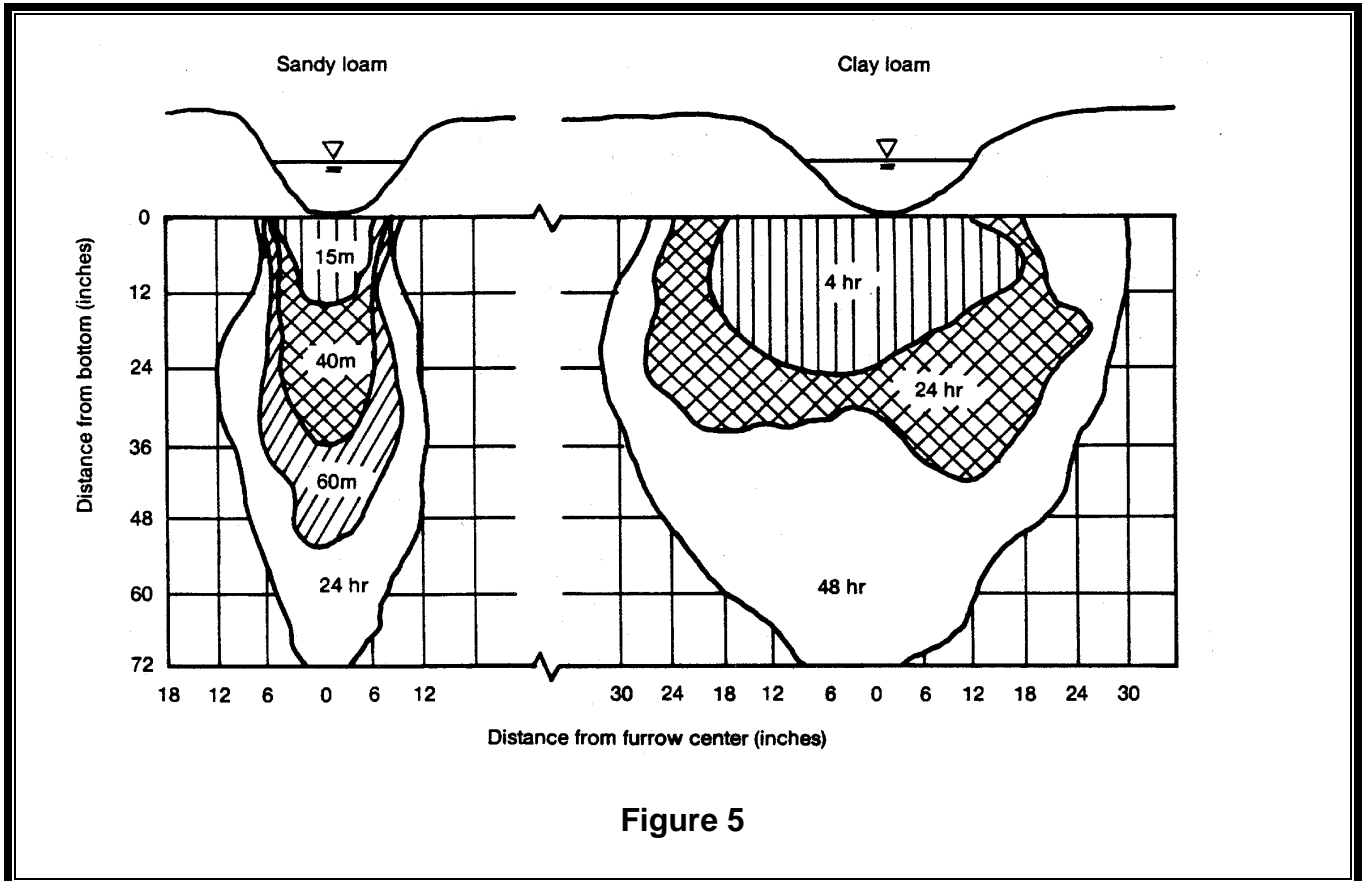


Figure 5

- b) Salts
Sodium salts cause soil particles to disperse, which has a negative effect on soil structure. Such soils tend to seal when wet, which slows infiltration and permeability rates drastically.
- c) Organic matter
Organic matter (decayed plant material) is desirable in the soil, not only because it improves soil fertility, but it also improves soil structure which has beneficial effects on permeability and infiltration.
- d) Compaction and pores
All soils contain pores. The pore spaces are occupied by either air or water (plant roots need both air and water). Fine textured soils (soils with high clay content) contain more total pore space than coarse textured soils (such as sandy loam and sand), however the pore spaces are smaller. Because of this, water moves slower through a fine textured soil.

Tillage pans are formed when farm implements repeatedly pass through the soil at the same depth. This action causes soil particles to be pressed closer together, reducing the amount of pore space and the size of the pores. Consequently, these pans have permeability rates lower than that of the soil above and below it. Soils may also have natural pans forms by cementing agents such as iron, silica, lime or gypsum.

A soil may be plowed or ripped to tear up natural or tillage pans and to increase the pore space in the soil. Also, deep-rooted cover crops might be used. In a gardening context, double-digging might be used.

The benefits of using some kind of tillage to break up soil compaction don't last forever. And while it is more difficult to break up compaction in a finer textured soil, the benefits will last longer than they will in a coarse textured soil. In a coarse textured soil, such as a sandy loam, most of the pore space added by plowing or ripping will be lost by the end of one cropping season.

- e) Structure
Soil structure has about the biggest effect on permeability. The cracks and pores between aggregates allow for the movement of air and water through the soil. Anything that improves structure improves permeability and vice versa. Tillage and irrigation affect soil structure. For example, heavy overhead irrigation or flood irrigation breaks down soil structure, which can lead to a sealing of the soil surface. This, in turn makes it more difficult for any further water to enter the soil. Tillage can help break up a soil that has become sealed, providing it is not done while the soil is too wet or too dry.
- f) Calcium
Calcium improves soil structure by encouraging aggregation. As a result it improves permeability and infiltration.
- g) Soil organisms
Microorganisms (bacteria and fungi) and macro-organisms (insects and earthworms) in the soil contribute to improved permeability and infiltration. They have a beneficial effect on soil structure because they encourage the formation of soil aggregates and they make pores in the soil.

4. Additional Properties influencing infiltration

- a) Dryness
Frequently, dry soils will repel water until they become moistened to some degree. This is especially true of soils that have high amounts of organic matter. (Do demo with peat moss).
- b) Surface fragments
A heavy cover of gravel and stones will prevent water from entering the soil and increase runoff. However, these types of soil are not usually cultivated.
- c) Fire

- A hot fire can produce resins and waxy materials that repel water.
- d) Slope

Slope may cause water to run off rather than enter the soil.

I. Available Water Capacity (AWC)

Definition: amount of water that the soil can hold that is **available for plant growth**. It is the difference between the amount of water in the soil at field capacity and the amount of water in the soil at wilting point. (See Appendix 1)

1. Field capacity-the amount of water the soil can hold against the flow of gravity. (1/3 bar or 33 kPa)
2. Wilting point-the moisture level at which the soil can no longer provide moisture for growth of most agronomic plants. (15 bar or 1500 kPa)
3. Measurement (in./in. or in./ft.)
AWC is usually measured in inches per foot or inches per inch. If it takes the addition of two inches of water to wet a dry soil to a depth of 1 foot, then the AWC is 2 inches per foot (.16 inches per inch). The available water capacity is then expanded to the number of inches of water the soil can hold within the rooting depth of the crop—usually to 60 inches or a root restricting layer, whichever is shallower.
4. Properties influencing water holding capacity
 - a) Texture

Soils that are high in clay content tend to have a higher available water capacity.
Soils that are high in sand content tend to have a lower available water capacity.
(See examples in Table 3)

Soil Texture	Available Moisture	
	Range in./ft.	Average in./ft.
Very Coarse to Coarse Textured (sands and loamy sands)	0.50-1.25	0.90
Moderately Coarse Textured (coarse sandy loam, sandy loam and fine sandy loam)	1.25-1.75	1.50
Medium textured (very fine sandy loam, silt, silt loam loam, sandy clay loam, clay loam and silty clay loam)	1.50-2.30	1.90
Fine and Very Fine Textured (silty clay, sandy clay and clay)	1.60-2.50	2.10
Organic soils (peats and mucks)	2.00-3.00	2.50
<p>Table 3. Available Water Capacity (AWC) for Various Soil Textures for Soils High in 2:1 Minerals (Soils high in Kaolinite or Gibbsite are about 20% lower)</p>		

- b) Salts

Salts reduce the Available Water Capacity of the soil. A soil that is salty can be wet and yet not have any water available for plant growth. This is because the salts have such a strong attraction for the water, that the roots cannot overcome it. (See Table 4)

EC of soil	4	6	12	16	18	20	22	25	30
% Reduction AWC	10	20	30	40	50	60	70	80	90
Table 4. Reduction in AWC for Salts									

- c) Organic matter

Organic matter is desirable in the soil, not only because it improves soil fertility, but it can also improve the Available Water Capacity.

d) Compaction

When a soil is compacted, the soil particles are pressed together which reduces the pore space which means there is less space for the water to occupy

e) Soil depth

Rooting depth is the depth to rock or other layer in the soil that restricts root depth. Natural hard pans as well as man-made pans may restrict root growth. The presence of a root restricting layer reduces the available water capacity of the soil, since it reduces the amount of soil that is available for plant roots.

One also needs to consider the natural rooting depth of the plants. For example, if the plant roots will only go to a depth of two feet in a soil with no root restrictions, then soil below two feet should not be considered when calculating available water capacity for that crop.

f) Coarse fragments

“Coarse fragments” refers to gravel, cobbles, stones and boulders in the soil—anything larger than 2 mm. Since coarse fragments do not hold water, their presence in the soil reduces its water holding capacity. (See Table 5)

Texture modifier	% Coarse fragments	% AWC_reduction
No modifier	0-15%	0-15%
gravelly, cobbly, stony, bouldery	15-35%	15-35%
very (gravelly, cobbly, stony, bouldery)	35-60%	35-60%
Extremely (gravelly, cobbly, stony, bouldery)	60-90%	60-90%

Table 5. Reduction in AWC for Coarse Fragments

5. Estimating AWC
(See Example 1).

IV. Introduction to basic chemistry concepts

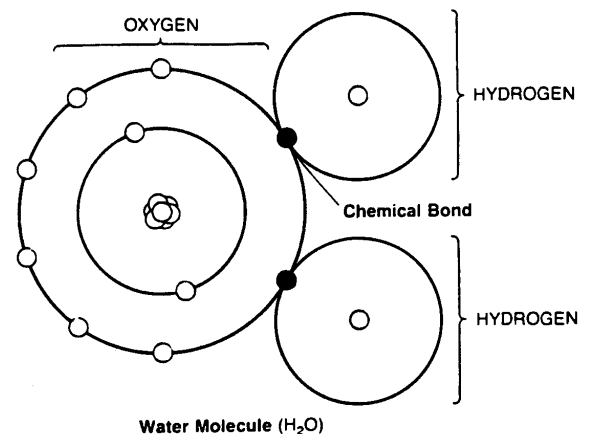
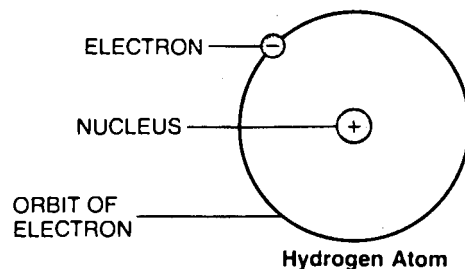
a. Atoms and Elements

Elements: basic unit of matter that can't be broken down by chemical means. They are the building blocks of nature. Each element is assigned a symbol of one or more letters derived from its Latin name. For example **O** is used for oxygen while **Fe** is used for iron.

Atoms: smallest part of an element that acts like that element. The simple *Bohr* model of a hydrogen atom, pictured here, gives a basic idea of the components of an atom. These models help us understand the chemical and electrical processes that happen in the soil.

The components of the atom are the **proton**, the **neutron** and the **electron**. The proton has a positive electrical charge and the neutron has no electrical charge. Protons and neutrons are in the center of the atom in what is called the nucleus. Usually there is an equal number of protons and neutrons +/- 1. Electrons are negatively charged and they orbit the nucleus.

b. Compounds, molecules and atomic



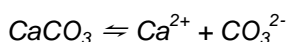
bonds

Atoms combine to form **molecules**. A collection of like molecules that consist of two or more different kinds of elements is called a **compound**. Molecules are represented by using the symbols of the elements with subscripts to tell how many there are of each. For example, water is represented H₂O, which means it has two hydrogen atoms and one oxygen atom.

One way that different atoms can join together is by sharing electrons. This is a type of chemical bond or **atomic bond**. An example is shown for water on the right.

c. Ions

A normal molecule has an equal number of protons (+) and electrons (-). Because of this they have a net negative charge of 0. However, frequently an imbalance occurs and the resulting atoms or molecules are called ions. This frequently happens when something dissolves in water. A **cation** is a positively charged ion (missing electrons), an **anion** is a negatively charged ion (has surplus electrons). An example is given below. In that example the superscripts indicate the number of ions missing (+) or surplus (-). If no number is given then it means only 1 electron is missing or surplus. A molecule in solution is usually in equilibrium with its constituent ions. In other words, some molecules are breaking into ions while other ions are recombining to form molecules.



Where:

CaCO₃ = Calcium Carbonate

Ca²⁺ = Calcium (cation)

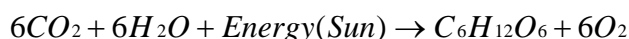
CO₃²⁻ = Carbonate (anion)

d. Elements needed by plants

1. From Water and Air
Carbon (C), Hydrogen (H), Oxygen (O)
2. From Soil
Nitrogen (N), Phosphorus (P), Sulfur (S), Potassium (K), Calcium (Ca), Magnesium (Mg), Copper (Cu), Iron (Fe), Manganese (Mn), Zinc (Zn), Boron (Bo), Molybdenum (Mo), Cobalt (Co), Chlorine (Cl)

e. Chemical reactions

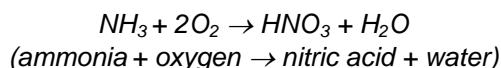
Chemical reactions occur when atoms are rearranged to form new molecules or compounds. For example, carbon dioxide and water can combine to form a sugar (as in photosynthesis). This reaction is written out like this:



(Note that since energy is required to make the reaction happen, this energy is released when the sugars are broken down. This opposite equation is called respiration and it is what happens in our bodies all the time: $\text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 + \text{Energy} \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O} + \text{Energy}$)

Oxidation/reduction reactions are special kinds of reactions that are very common and important in nature. **Oxidation** occurs when an element or molecule loses an electron and some other element or molecule gains the electron (**reduction**). The **electron donor** is said to be oxidized and the **electron acceptor** is referred to as reduced. The term "oxidized" is used because it is usually oxygen that accepts the electrons (and thus increases quantity in the new molecule).

A common oxidation reaction occurs in the soil when ammonia is added. Ammonia is oxidized to form nitric acid (Notice how oxygen becomes part of the new molecule in this equation.)



f. **Adsorption vs. absorption**

Adsorption and absorption are two terms used in soil science that can get confused.

Adsorption means to be held onto the outside of something. In soils this refers to how ions are held to the edges of mineral and organic particles.

Absorption means to be taken up into something such as water being taken up by a sponge or nutrients taken into plant roots.

Picture a life raft at sea. Absorbed would be the people in the life raft, adsorbed would be the people hanging to the outside of the life raft.

g. **Organic vs. organic**

Organic is another confusing term. To the chemist, organic refers to many kinds of compounds containing carbon, which may be natural or synthetic. Many of the synthetic pesticides used are organic by this definition.

Organic also refers to agricultural techniques based on maintaining soil fertility through organic matter. Such systems do not use synthetic organic chemicals, but they may use naturally occurring inorganic soil amendments.

V. **Soil Colloids**

a. **Definition**

colloid - A particle, which may be a molecular aggregate, with a diameter of 0.1 to 0.001 μm . Soil clays and soil organic matter are often called soil colloids because they have particle sizes that are within, or approach colloidal dimensions. Colloids go into suspension in a solution—they float around without settling out for great lengths of time.

b. **Importance**

Colloids have properties that are important in soil chemistry, such as the ability to adsorb cations.

VI. **Soil Solution**

a. **Definition**

Usually the water in the soil is referred to as the **soil solution** because it contains dissolved materials (cations and ions) and well as suspended colloids of clay and organic matter.

While plants tend to get their nutrients from the soil solution, the solution does not contain sufficient nutrients at any one time to last the life of the plant. Usually these nutrients are replenished from the pool of *exchangeable* nutrients (those which are adsorbed onto colloids, see CEC, below). Still more nutrients are held in what is called the *stable pool* (bound up in solid form as minerals or organic matter).

VII. **Cation Exchange Capacity (CEC) and Base Saturation**

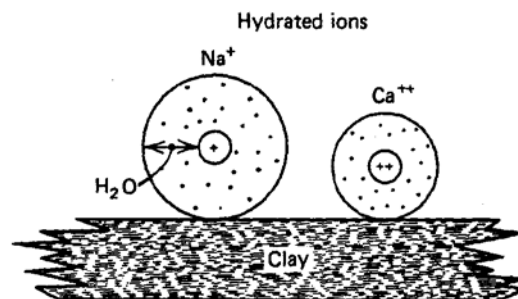
a. **CEC**

Definition: Ability of the soil to adsorb cations

It is primarily the ionic form of nutrients that plants are able to take up into their roots. Many of these nutrients are taken up in the cationic form, so it is important that the soil be able to supply these.

Most soils have at least some ability to hold onto these ions at negatively charged sites within the soil. The amount that they can hold is called the **Cation Exchange Capacity**. The cations are held to the edges of particles within the soil. This is referred to as adsorption. (Use magnets to demonstrate attraction of positive and negative.)

Calcium ions are more strongly adsorbed by clay than sodium ions, because calcium is divalent and has a smaller hydrated radius.



From Foth, 1984, p. 194

The cations in the soil are divided into acids and bases. The **acids** are predominantly hydrogen and aluminum. The **bases** are primarily calcium, magnesium, sodium, potassium.

A more technical definition of CEC would be:

The sum of exchangeable bases plus total soil acidity at a specific pH value, usually 7.0 or 8.0. When acidity is expressed as salt extractable acidity, the cation exchange capacity is called the effective cation exchange capacity (ECEC) because this is considered to be the CEC of the exchanger at the native pH value. It is usually expressed in centimoles of charge per kilogram of exchanger (cmolckg⁻¹) or millimoles of charge per kilogram of exchanger.

1. Measurement (meq/100g soil or cmol/kg (new units, numbers are the same))
2. Factors influencing CEC
 - a) Amount and type of clay
Higher amounts of clay mean higher CEC. Certain kinds of clay (smectites, montmorillonite) have higher CEC than others (such as kaolinite).
 - b) Amount of organic matter
Higher amounts of organic matter mean higher CEC
 - c) pH dependent CEC
Amorphous clay minerals and organic matter have a CEC that varies with pH. As pH increases, so does the CEC. Under acid conditions, these have an anion exchange capacity.

b. Base saturation

1. definitions

In simple terms, **base saturation** refers to the percentage of exchange sites (negatively charged sites on clay and organic particles) that are occupied with bases (usually Ca²⁺, Mg²⁺, K⁺ and Na⁺) as opposed to ions that make the soil acid (H⁺ or Al³⁺). A more technical definition is the ratio of the quantity of exchangeable bases to the cation exchange capacity. The value of the base saturation varies according to whether the cation exchange capacity includes only the salt extractable acidity (see cation exchange capacity) or the total acidity determined at pH 7 or 8. Often expressed as a percent.

exchangeable bases - Charge sites on the surface of soil particles that can be readily replaced with a salt solution. In most soils, Ca²⁺, Mg²⁺, K⁺ and Na⁺ predominate. Historically, these are called bases because they are cations of strong bases. Many soil chemists object to this term because these cations are not bases by any modern definition of the term.

2. significance

Soils with high base saturations are considered more fertile because many of the "bases" that contribute to it are plant nutrients. Usually the base saturation is 100 percent when the pH above about 6.5

VIII. Anion Exchange

a. Introduction

Anions are not adsorbed onto soil particles to anywhere near the extent that cations are. This is due to the fact that clay minerals only have negative charges and that most of the exchange sites in organic matter also have negative charges.

Many of the anionic nutrients are supplied through organic amendments from which they are released as the organic matter breaks down. Because there is little adsorption of the anions, many (particularly nitrates) are easily leached which can lead to groundwater contamination. This can even happen in an organic farming situation if it is not well managed.

Nutrients that are usually supplied by anions are nitrogen (NO₃⁻), phosphorus (H₂PO₄⁻, HPO₄²⁻), sulfur (SO₄⁻), chlorine (Cl⁻), boron (B₄O₇²⁻) and molybdenum (MoO₄⁻).

b. Definitions

anion exchange capacity - The sum of exchangeable anions that a soil can adsorb. Usually expressed as centimoles, or millimoles, of charge per kilogram of soil (or of other adsorbing material such as clay).

exchangeable anion - A negatively charged ion held on or near the surface of a solid particle by a positive surface charge and which may be easily replaced by other negatively charged ions (e.g. with a Cl⁻ salt).

IX. pH

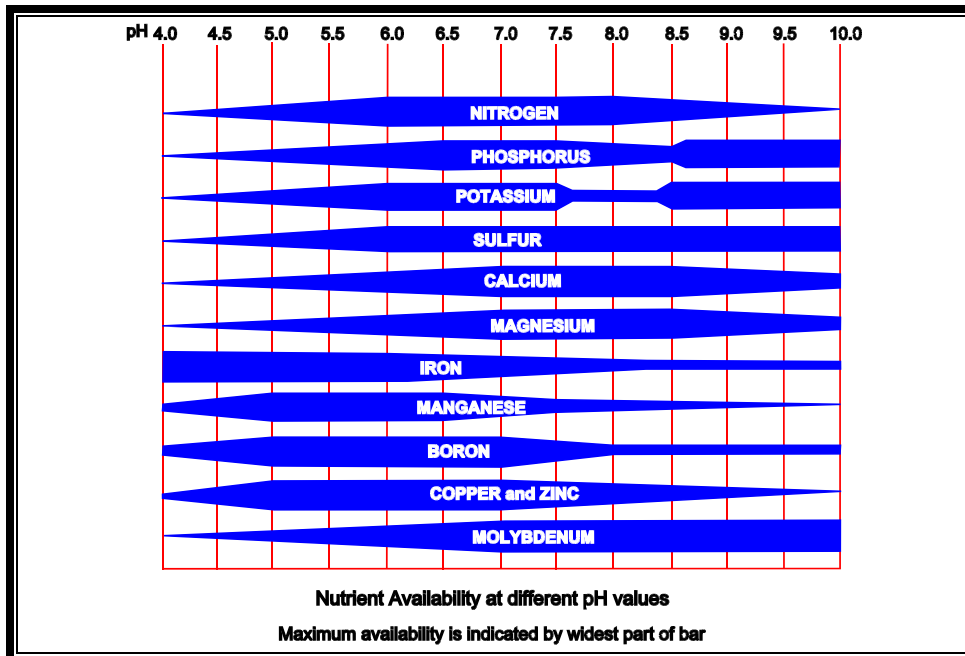
a. What is pH?--

pH stands for “potential of hydrogen” and it is expressed as the negative of the log of the concentration of hydrogen ions (moles per liter); it is a number between 0 and 14. (Water, H₂O or HOH is usually in equilibrium with its constituent ions, H⁺ and OH⁻ and has a pH of 7.) In acid soils (pH < 7), H⁺ ions predominate. In alkaline soils (pH > 7), OH⁻ ions predominate. Soils with pH of 7 are neutral. (Demonstrate different methods of measuring pH.)

Reaction	pH	Reaction	pH
Ultra acid	<3.5	Neutral	6.6-7.3
Extremely acid	3.5-4.4	Slightly alkaline	7.4-7.8
Very strongly acid	4.5-5.0	Moderately alkaline	7.9-8.4
Strongly acid	5.1-5.5	Strongly alkaline	8.5-9.0
Moderately acid	5.6-6.0	Very strongly alkaline	>9.0
Slightly acid	6.1-6.5		

b. Effect of pH on nutrient availability and uptake

pH does not directly affect plants. It does affect the availability of different nutrients and toxic elements to plants. This is mostly due to the fact that pH changes the form of many of the nutrients and many of the forms are relatively insoluble.



X. Acidity

a. Definitions

Acidity refers to the condition of the soil when the exchange complex is dominated by **hydrogen** and **aluminum** ions

b. Distribution of acid soils

Acid soils usually occur where there is sufficient rainfall or other sources of rainfall to leach the bases out of the soil. When this happens, the exchange complex becomes dominated by hydrogen (lowers pH) and aluminum (toxic). In the US there is a fairly strong correlation between precipitation and pH, with soils receiving more than about 30 inches of precipitation having a pH less than 6.

c. Problems associated with acidity

Aluminum toxicity—Aluminum is the third most common element in the earth's crust. It becomes more available at low pH's, and can be toxic to plants.

Manganese toxicity—This may occur in soil that are high in Mn and that have a pH less than 5.

d. Acid soils and liming

Lime (calcium carbonate) is added to acid soils to raise the pH. Calcium replaces hydrogen and aluminum on exchange sites. For a good reference on liming, get the Soil Quality Technical note Number 8 from the website:

<http://www.statlab.iastate.edu/survey/SQL/agronomy.shtml>

XI. Alkalinity, Alkali, Salinity and Sodic Soils

a. Definitions

alkalinity, soil - The degree or intensity of alkalinity in a soil, expressed by a value >7.0 for the soil pH.

alkali soil - (i) A soil with a pH of 8.5 or higher or with an exchangeable sodium ratio greater than 0.15 (ESP >15). (ii) A soil that contains sufficient sodium to interfere with the growth of most crop plants. See also saline-sodic soil and sodic soil

saline soil - A nonsodic soil containing sufficient soluble salt to adversely affect the growth of most crop plants. The lower limit of saturation extract electrical conductivity of such soils is conventionally set at 4 dS m⁻¹ (at 25 ° C). Actually, sensitive plants are affected at half this salinity and highly tolerant ones at about twice this salinity.

sodic soil - A nonsaline soil containing sufficient exchangeable sodium to adversely affect crop production and soil structure under most conditions of soil and plant type. The sodium adsorption ratio of the saturation extract is at least 13.

saline-sodic soil - A soil containing sufficient exchangeable sodium to interfere with the growth of most crop plants and containing appreciable quantities of soluble salts. The exchangeable sodium ratio is greater than 0.15, conductivity of the soil solution, at saturated water content, of >4 dS m⁻¹ (at 25 ° C), and the pH is usually 8.5 or less in the saturated soil.

b. Some elements contributing to alkalinity

Calcium—Calcium is common in many soils in arid areas. It helps the soil to form aggregates. (Because it has a +2 charge (divalent), it can bind to two clay or organic particles).

Magnesium—behaves similar to calcium in helping to form aggregates.

Potassium—an important plant nutrient

Sodium—See section on sodicity below.

c. Salinity (Electrical Conductivity-EC)

Salinity refers to the presence of salts. Since saline soils conduct electricity, it is usually measured as Electrical Conductivity—EC. The units for EC are mmhos/cm or dS/m (millimhos per

centimeter or decisiemens per meter). A soil is considered saline if it has an $EC > 4$ (though some plants cannot tolerate even this much). Saline soils mainly occur in dry areas. The reason plants cannot tolerate salinity is either due to the toxic effect of certain salts or to the fact that salts can hold on to the water tightly that the plants cannot get it. Non-saline water may not infiltrate saline soils very easily. When irrigating saline soils with water that has a low salt content, it may be necessary to add gypsum to the water so that it will infiltrate the soil.

In order for there to be salts in the soil, there must be a source for them. For example, in many parts of California, there are old marine beds, which contain salts that have been lifted into various mountain ranges. Also, there is some sodium present in feldspars which is released upon weathering. (The granite, which makes up much of California is a source of such feldspars.) If there is sufficient rainfall to leach out these salts and if there is a watershed to carry the salts out to the ocean, then these salts won't be a problem. However, in many parts of California there is usually not enough precipitation to accomplish this and also, in many places, there are closed basins that do not drain to the ocean. Frequently, in these areas there are playas—salty basin floors that may hold intermittent, saline water.

The salts that usually contribute to soil salinity are magnesium (Mg^{2+}), sodium (Na^+), calcium (Ca^{2+}), chloride (Cl^-), sulfate (SO_4^{2-}), bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}).

d. Sodicty—

Sodicty refers to the presence of **sodium**. Many saline soils are also sodic (though it is possible for a soil to be sodic and not saline). Sodium is toxic to plants. It also causes soil particles to disperse (separate) which causes cracking and sealing of the soil surface. Sodium in the soil is usually expressed in the term **Sodium Adsorption Ratio (SAR)** which reflects the degree to which the exchange sites in the soil are occupied by sodium (rather than other cations). A soil with a SAR greater than about 13 is considered to be sodic. Sometimes the term **Exchangeable Sodium Percentage (ESP)** is used instead. An ESP of 15 is roughly equivalent to a SAR of 13.

Sodic soils can be reclaimed with a two step process. First the sodium is flushed from exchange sites by adding amendments containing calcium (such as lime, gypsum or dolomite) or by adding sulfur followed by calcium. (The sulfur is converted to sulfuric acid by microbial activity. The acid reacts with lime to free calcium.) The next step is to leach out the sodium salts by providing water in excess of what the plant needs.

e. Distribution

Alkaline soils usually occur where there is insufficient rainfall to leach the bases out of the soil, that is, where annual evapotranspiration is greater than the precipitation.

XII. Soil as a medium for plant growth

a. Nutrient uptake processes

(This section is from the following website which is no longer available:

http://www.ag.usask.ca/departments/scsr/departement/outreach/dlcourses/soils/soilfert/soilfert_ion.html)

Imagine you are a tiny creature trying to move around in the soil. Can you imagine the millions of pores of all sizes and shapes, many of which are blocked by organic matter and mineral particles? The surfaces of these pores are very active and are capable of adsorbing ions and organic molecules. Once you have found your way around, the system changes with each wet-and-dry, or freeze-and-thaw cycle. Maybe a burrowing animal drops by and creates a real mess of your little world. In short, the soil is a constantly changing system that has numerous barriers to the movement of organisms and chemicals.

In terms of soil fertility we are greatly interested in the soil physical system. For a nutrient to be available for the plant to take up it must first be in the proper chemical form to pass the root membrane and most importantly it must be available at the root surface.

The movement of nutrients in soil is dependent on

- their concentration in soil solution;
- how strongly they are adsorbed by clays and organic matter,

- and how fast they can move.

For any given nutrient if we know how it moves in soil then we can use this information to formulate and place fertilizers.

As an example: phosphorus exists in soil solution as the orthophosphate ion (H_2PO_4^- or HPO_4^{2-}) in very low concentrations and is strongly adsorbed by the soil surfaces. In contrast, nitrogen usually has a much greater concentration in soil solution (usually as NO_3^-), and is very weakly adsorbed. Knowing these facts we then can determine that we must place phosphorus fertilizers very close to the seed to be effective whereas nitrogen can be broadcast over the surface of the soil where it can be washed down to plant roots.

Nutrients move through the soil to plant roots in three ways:

- Root Interception
- Mass Flow
- Diffusion

Each nutrient will have one or more of these methods of movement depending on its chemical form and soil physical and chemical conditions.

Root Interception

This is probably a weird way to look at movement of nutrients, since it is the root that moves to the nutrient. The roots of plants are constantly expanding (opening up blocked pores as they do so) and they grow from areas of depleted nutrients (e.g. because of plant uptake) to other regions where nutrients more concentrated. These nutrients may be adsorbed on soil surfaces or in locked in fertilizer pellets.

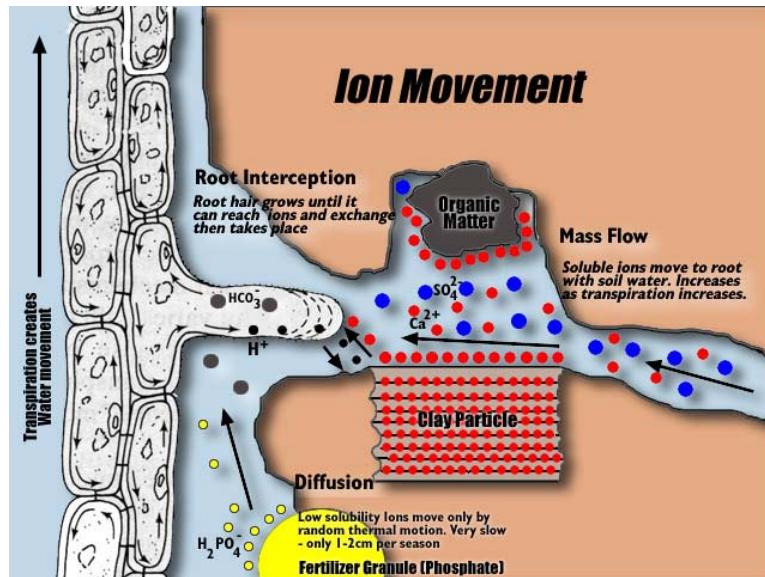
Although many plants such as cereals and grasses have a very extensive root system, they only can contact less than 5% of the soil volume. The root interception mechanism is very valuable, however, because root growth can extend to areas where mass flow and diffusion take over. For example, a root could grow within a few millimeters of some soil phosphorus pellet. Although the root does not technically bump into the nutrient and intercept it, the root is close enough for diffusion to occur.

Mass Flow

Growing plants are continually absorbing water from the soil profile. Dissolved in this water are soluble nutrients. These nutrients are transported along with the water to the root surface. Nutrients that are strongly adsorbed to the soil surfaces, like phosphorus, would never get there. But nutrients, like nitrogen, that are held very weakly by soils readily move along with the water. Nutrients that move by mass flow are those which have a high concentration in soil solution relative to the plant requirements e.g. nitrate and sulfate.

Diffusion

The random movement of ions in response to thermal energy is called diffusion. Imagine you have a tank of water with a removable barrier in the middle. On one side of the barrier you have ink, the other side pure water. When you remove the barrier very slowly you will see the ink and water mixing due to random movement of molecules. This is the process of diffusion. Similarly if we place a particle of fertilizer into soil it will slowly dissolve and the solution will spread out slowly and mix with the soil solution. How slow is diffusion? Phosphorus will rarely move more than a few millimeters from a fertilizer granule in a whole growing season! It very important that we place this fertilizer so that the root can intercept it. Diffusion is the dominant mechanism of movement for phosphorus and most of the micronutrients.



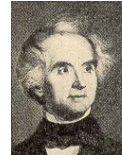
XIII. Plant nutrient requirements

a. Introduction

1. Nutrient Balance

Before we begin our discussion of nutrient requirements, we need to consider the concept of balance. Even though it is easier to consider one nutrient at a time, it is important to think of plant needs holistically. Supplying one nutrient while ignoring other plant needs (nutrients and environmental factors) may not benefit the plant at all and, in fact, may be bad for the crop.

Justus von **Liebig** (1803-1873) analyzed plant samples and proposed a **law of the minimum**. This law states that plant growth is proportional to the amount available of the most limiting plant nutrient. For example, if I supply nitrogen sufficient to produce 70 bushels of wheat per acre but only supply enough phosphorus for 50 bushels per acre, then I will get only 50 bushels per acre (providing everything else is sufficient). This concept has since been expanded to include not only nutrients but also such things as water, temperature and other soil factors.



As important as Liebig's contributions are, they do not go far enough in addressing the situation holistically. In the above example, for instance, nitrogen that is applied in excess of what the crop will consume is in danger of being leached into the groundwater where it will become a pollutant. Also, application of too much of any one nutrient can be injurious. For example, if too much nitrogen is supplied to tomatoes relative to the amount of phosphorus supplied, the tomatoes may grow very pretty plants but not produce any fruit.

The advantage of organic farming and gardening is that natural and organic soil amendments, unlike many synthetic ones, frequently supply many more nutrients than the primary one for which it is used, especially in regard to micronutrients.

2. Feed the Plant or Feed the Soil

One of the main distinctives of organic farming and gardening is its emphasis on *feeding the soil* rather than on *feeding the plant* (which most contemporary agricultural practices do). The idea is that if the soil is happy, the plant will be happy. However, we still need to keep in mind the nutrient needs of the plant, because the plant may need some nutrient of which the soil is perfectly content to do without.

The reason for this is that most soils are well suited to supply the needs of the native vegetation. And while a soil may have no problem supporting, let's say, southern hardwoods, it may be ill prepared to nurture a field of corn.

3. Macronutrients and micronutrients

Plant nutrients are divided into two categories. **Macronutrients** are those that build up the bulk of the plant and so are needed in large quantities. **Micronutrients** are needed in small quantities,

but are no less important. However, deficiencies of these are less likely to occur. Macronutrients include nitrogen, phosphorus, potassium, sulfur, calcium and magnesium. Micronutrients include boron, copper, iron, manganese, molybdenum, zinc, chlorine and cobalt.

4. Nutrient cycling

The amount of each chemical element in the world (with some exceptions) is fixed. Consequently, if remove all of one element from a location, its not going to be available there anymore unless it gets put back. This is a very important consideration in soil chemistry and plant nutrition. Many nutrients never leave the farm and are recycled through the use of things like manures and compost. But many nutrients are exported from a farm (in the crop or down the sewer, for example), and there needs to be a way to replace those nutrients in the soil. Looking at things this way, farming and gardening are nothing more than moving ions and nutrients around.

Some of the details of different nutrient cycles will be considered further when individual nutrients are discussed.

5. Mobility of nutrients within the plant

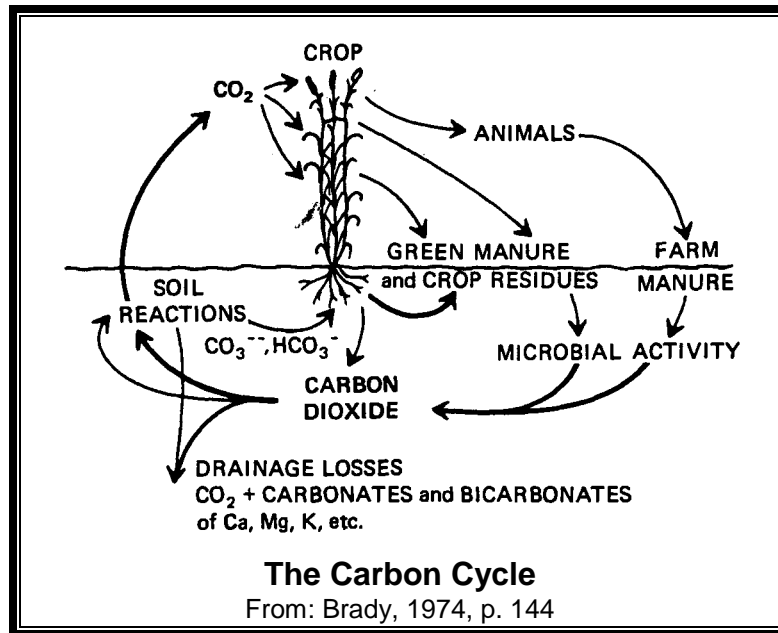
Some nutrients are mobile within plants; others remain where they are. This affects how nutrient symptoms appear. Nutrients that are mobile can move from older leaves to newer, growing tissues when there is a deficiency of them. Consequently, when these are lacking, symptoms appear in the older (lower and inner) leaves first. Nutrients that are immobile cannot be translocated to young, new growth. As a result, deficiency symptoms will appear in younger (upper and outer) tissues first. Nutrients that are mobile include nitrogen, potassium, phosphorus, magnesium, molybdenum and zinc. Nutrients that are immobile include sulfur, calcium, iron, manganese, boron and copper.

b. Carbon, Hydrogen and Oxygen

Most of the bulk of plants and animals is made up of Carbon, Hydrogen and Oxygen. A common term for these compounds is carbohydrates. Plants get these elements primarily from air (carbon dioxide--CO₂) and water (H₂O). This happens in the leaves of plants during photosynthesis:



Carbon is the core element of the large organic molecules that comprise all living things. It combines with elements such as hydrogen, oxygen, nitrogen, sulfur, phosphorus and other carbon atoms to form not only carbohydrates, but also fats, proteins and other compounds. In recent years there has been renewed interest in carbon due to its purported role in global warming. In some areas they are practicing **carbon sequestration**--an attempt to build up reserves of carbon in the soil to keep it from being released to the atmosphere as *greenhouse gases*.



c. Nitrogen (N)

1. Physiological role in plant development

Plants take up nitrogen either as the ammonium ion (NH_4^+) or nitrate (NO_3^-). Most organic compounds in plants contain nitrogen including amino acids, nucleic acids, many enzymes and energy transfer materials such as chlorophyll, ADP, and ATP. N is necessary for the production of sugars such as is found in sweet ripe fruit. Growing plants must have nitrogen to form new cells. Consequently, plants cannot function without nitrogen.

2. Soil nutrient deficiencies, imbalances, toxicity

Nitrogen deficiency symptoms include:

- Slow growth, stunted plants
- Yellow-green color (chlorosis)
- Firing (burnt look) of tips and margins of leaves beginning with more mature leaves.
- Low protein content of crops

Symptoms of nitrogen excess include:

- Dark green, succulent, vegetative growth at the expense of seed production in grain crops, fruit production in tomatoes and some tree crops and sugar content in beets.
- Watery potatoes
- Frost damage if there is too much succulent growth when frost hits.
- Weakened stems (lodging)
- Flowering or fruiting delayed
- Boron or Copper deficiency due to inhibited uptake of these nutrients

3. Forms of nitrogen in the soil

Nitrogen occurs in the soil in various forms:

- Nitrogen gas in the soil air (N_2)
- Nitrate (NO_3^-)
- Nitrite (NO_2^-)
- Ammonium (NH_4^+)
- Ammonia (NH_3)--a gaseous, transitory form
- In various other forms as part of complex organic molecules frequently as an amine group ($-\text{NH}_2$)

4. Nitrogen fixation

Nitrogen gas makes up about 70% of the atmosphere. It is a very stable form of nitrogen, but it is unavailable to plants. Certain bacteria (*Rhizobium*) and actinomycetes (*Frankia*) are able to

transform nitrogen gas into nitrate. This is called **biological nitrogen fixation** (as opposed to industrial nitrogen fixation carried out by chemical factories). The microbes form symbiotic relationships with plants in which the plants provide food to them and they provide nitrogen to the plants. *Rhizobium* is a genus of bacteria that work almost exclusively in plants of the bean (legume) family. *Frankia* are actinomycetes that are active with plants such as alder (*Alnus* spp.), bayberry (*Myrica* spp.), ornamental "olives" (*Elaeagnus* spp.), ceanothus (*Ceanothus* spp.) and Australian pine (*Casuarina* spp.). There are also some species of free-living cyanobacteria that are able to fix nitrogen. These frequently form *cryptobiotic* or *microbiotic crusts* that can be important parts of desert ecosystems. Some nitrogen fixing cyanobacteria live in conjunction with other organisms to form lichens.

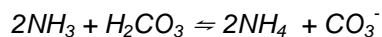
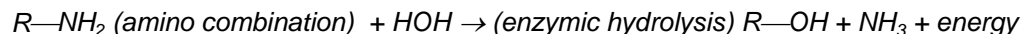
In many cases, there may not be sufficient *Rhizobium* or *Frankia* in the soil to give a good boost to the crop. Or it may be that the type of *Rhizobium* is not the right species for the crop you are planting (not all *Rhizobium* species work with all species of legumes). In this case it may be necessary to inoculate the seed when the crop is planted. Inoculants are supplied by many of the companies that sell legume seed.

Inoculating legume seed does not mean that it will not be necessary to supply additional nitrogen to the crop. The *Rhizobium* themselves will need nitrogen to get started and the crop must have sufficient nitrogen to last until the *Rhizobium* are producing enough. Also, *Rhizobium* need sufficient Phosphorus, Iron, Molybdenum and Cobalt in order to live.

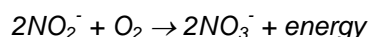
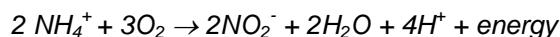
Nitrogen can also be fixed by lightning (with the nitrates then being carried to ground by rainfall), combustion (as in nitrous oxides in auto exhaust), or through synthetic processes (as in the manufacture of nitrogen fertilizers).

5. Nitrification and Mineralization

Mineralization (aminization and ammonification) is the release of ammonium ions from decomposing organic matter. Many microbes are capable of doing this, so an environment that is favorable to microbial growth makes for fairly rapid ammonification. The ammonium that is produced is *held in the soil solution, adsorbed onto cation exchange sites or taken up by plants*. An example of a mineralization reaction is:



Nitrification is a two stage process in which ammonium is transformed into nitrate (which is more readily taken up by plants). This, too, depends on microbial activity, but there are specific bacteria involved. *Nitrosomas* spp. (and a few others) oxidize ammonium to nitrate and *Nitrobacter* spp. oxidize nitrite to nitrate.



6. Denitrification

Nitrogen can be lost from in wet soils where *anaerobic* (oxygen free) conditions occur. Under these conditions specialized bacteria can get their oxygen from nitrate (rather than oxygen), releasing nitrogen gas back into the atmosphere. This process is called denitrification. Though nitrogen can be lost from the ecosystem this way, denitrification can be very useful function where excesses of nitrate occur in the soil. Note that even well drained soils may have parts that become anaerobic at some times.

To minimize denitrification one should maintain good aeration (structure) in the soil, keep the pH near neutral, avoid over-fertilization with nitrate, and incorporate residues in the upper few inches of the soil where there is more oxygen

7. Immobilization

Nitrogen is unavailable to plants (immobilized) when it is in the organic form. Usually rates of mineralization in the soil are higher than rates of immobilization. However, if organic matter added to the soil has less than 1.5% N, the rate of immobilization will temporarily exceed the rate of mineralization, decreasing the amount of N available to plants.

Carbon-Nitrogen Ratios

Microbial action can either mineralize or immobilize nitrogen. The main factor in determining which will happen is the carbon to nitrogen (C:N) ratio. Microbes use carbon (from organic matter) for bodybuilding as well as for energy. The nitrogen entering their bodies needs to be in a fixed ratio to the amount of carbon. The critical range of the C:N ratio is 25:1 to 35:1. Ratios wider than this (caused by the addition of residues with a C:N ratio higher than this) will cause N to be immobilized. Narrower ratios will permit N to be freed as organic matter decomposes. Most plant residues have C:N ratios of 20:1-100:1 (see page 79 in text); the bodies of microorganisms have a C:N ratio of 4:1 to 9:1. Usually the organic matter in the soil stabilizes with a C:N ratio somewhere between 8:1 to 15:1.

8. Losses of Nitrogen through leaching and volatilization

Nitrogen is one of the easiest nutrients lost from the system. Nitrogen, especially ammonia, is easily volatilized. Amendments left on the soil surface will rapidly lose the nitrogen value. Volatilization is higher with warmer temperatures.

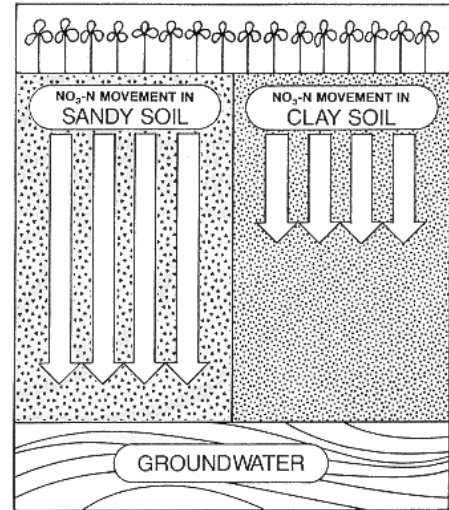
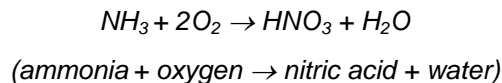
Nitrogen is also easily leached. This is not only a loss to the crop because the nitrates can contaminate the groundwater, making it toxic. Leaching is most likely to occur in sandy soils, fallow areas or in soils low in organic matter.

"The more one tries to force nitrogen into the soil, the greater are the chances of nitrogen losses" (Parnes, 1990, p. 75)

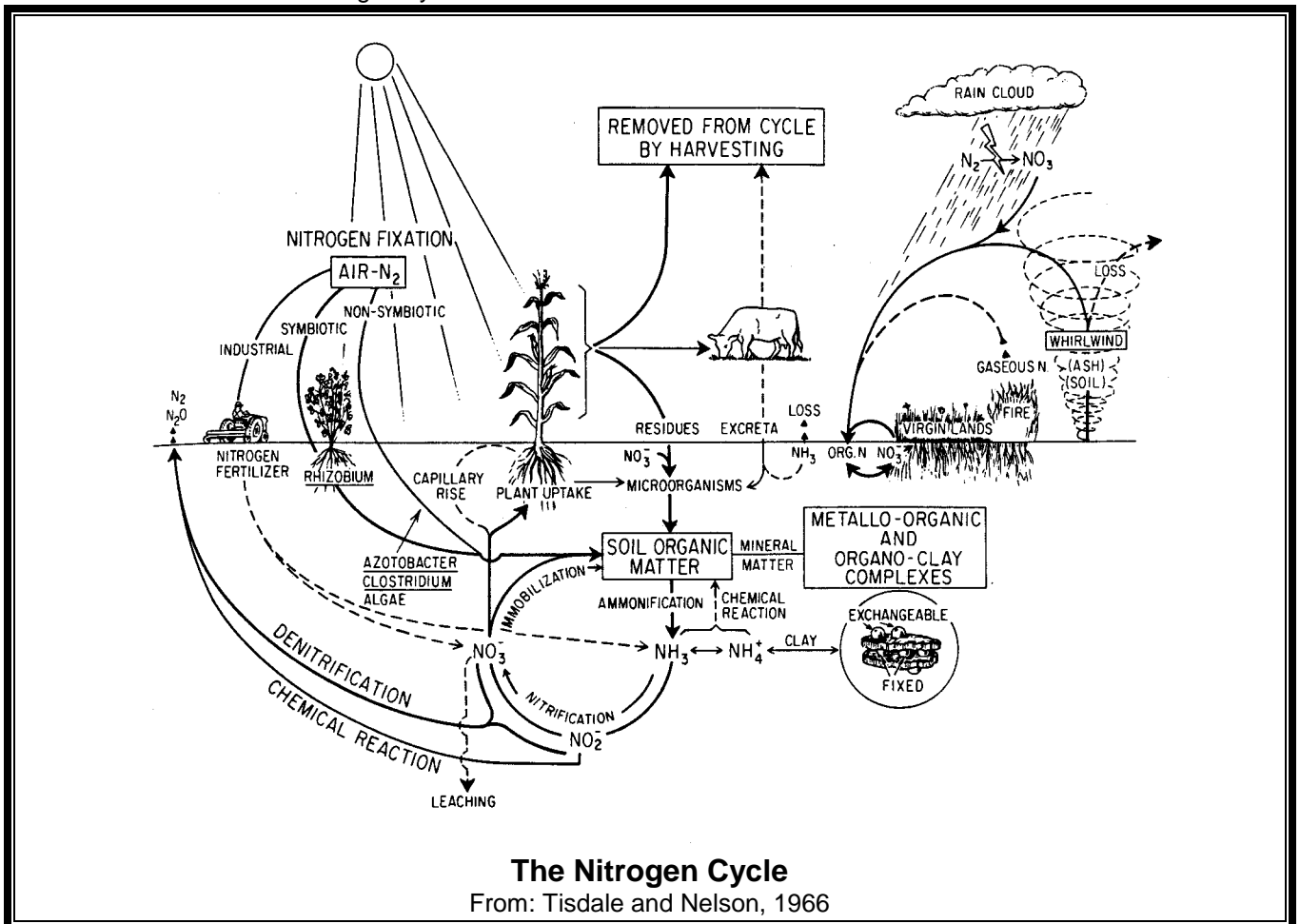
9. Supplying nitrogen to the soil.

There are many ways that nitrogen can be supplied to the soil. These include green manures, crop rotation with leguminous crops and amendments. Amendments that can be used to supply nitrogen include animal manures, guano, cottonseed meal, bone meal, hoof and horn meal, bloodmeal, peanut shells and fish emulsion.

Care must be taken when using amendments high in ammonia (such as fresh poultry manure). Ammonia is a strong base which can "burn" plants. However, its use over an extended period of time will acidify the soil as bacteria oxidize the ammonia to form nitric acid. The chemical formula for this is:



10. The nitrogen cycle



d. Phosphorus (P)

1. Physiological role in plant development

Phosphorus is present in all living cells. It is used by plants to form nucleic acids (DNA, RNA) and is used in the storage of energy trapped by photosynthesis and its transfer. Phosphorus also stimulates early growth and root formation and it hastens maturity (bloom time) and promotes seed production and size. It is used in protein synthesis and it is found in legume nodules.

2. Soil nutrient deficiencies, imbalances, toxicity

Phosphorus must be balanced with nitrogen both in the plant and in the soil. In the soil, P and N compete to be taken up. Because N is highly mobile and P is one of the least mobile nutrients (both in the plant and in the soil), excessive N can cause a P deficiency even if there is enough P in the soil for the crop.

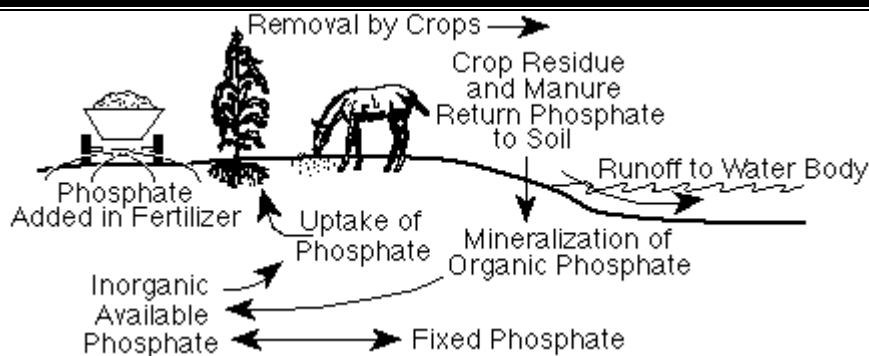
In the plant, N is required to trap energy, but P is required to facilitate its transfer. Also, N is a primary ingredient of protein but P is required for its synthesis.

Phosphorus deficiency symptoms include:

- Slow growth, stunted plants
- Purplish coloration on foliage of some plants
- Dark green coloration with tips of leaves dying
- Delayed maturity
- Poor grain, fruit or seed development

3. The Phosphorus cycle

Phosphorus is not easily leached from the soil as it remains bound to soil particles. Consequently, the main losses of P from the system are either by export of crops or by soil erosion. Most phosphate pollution of lakes and streams is from sediment that is high in P.



The Phosphorus Cycle

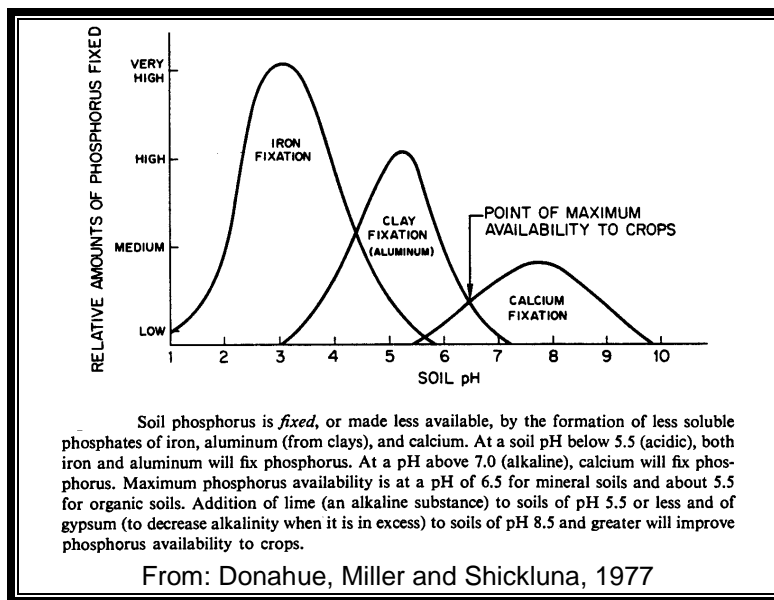
From: <http://www.extension.umn.edu/distribution/cropsystems/DC6795.htm>

4. Phosphorus in soils and factors affecting its availability

Phosphorus is taken up as H_2PO_4^- or HPO_4^{2-} or PO_4^{3-} depending on pH. H_2PO_4^- more available in very acid conditions while PO_4^{3-} is more available in very alkaline conditions. Most of the total P in the soil is tied up in compounds with limited solubility. In neutral to alkaline soils, it is usually bound as calcium phosphate while in acid soils it forms iron and aluminum phosphates. Maximum availability occurs between pH 6.5 and 7.2.

Some soils are capable of *fixing* (binding nearly irreversibly) phosphorus when the P gets bound with reactive forms of iron, aluminum and manganese. The fixing capacity of a soil is largely dependent on the amount and types of clay present in the soil. Clays made up of iron, aluminum and manganese oxides or allophane have high P fixing ability. These clays are commonly found in warm humid climates (Oxisols and Ultisols) and areas affected by volcanic ash (Andisols). Usually these conditions are dealt with by adding enough P to the soil to satisfy its P fixing ability.

Phosphorus is highly immobile and roots only take up what is only a fraction of an inch away, so if the P is not close to the root, it will not be available. Maintaining adequate moisture throughout the growing season will facilitate P movement. Phosphorus availability is also affected by temperature. In cool temperatures P may show deficient in plants even though there is enough present for the plant needs. As temperatures warm, deficiency signs may go away. Organic P tends to be more available than inorganic, so use of organic amendments, along with promoting biological activity, will make P more available.



5. Phosphorus in amendments

The best source of phosphorus to use in the garden is "recycled"--compost and manures. Compost and manures are fairly low in P content but may have more *available* P than some other

sources. Poultry manure has the highest amounts. Organic amendments should have a pH between 6.5 and 6.8 to maximize availability. If these are not sufficient to meet needs, bone meal (finely ground bones from slaughterhouses) or colloidal or rock phosphate are some sources that are high in phosphorus. The negative side to bone meal is that it is usually dependent on large scale confined animal operations. Colloidal and rock phosphates come from non-renewable sources. Another drawback to bone meal and rock phosphate is that, while they are P rich, the phosphorus is slowly available and most of what is applied serves more for crops to be planted in following years.

e. Potassium (K)

1. Physiological role in plant development

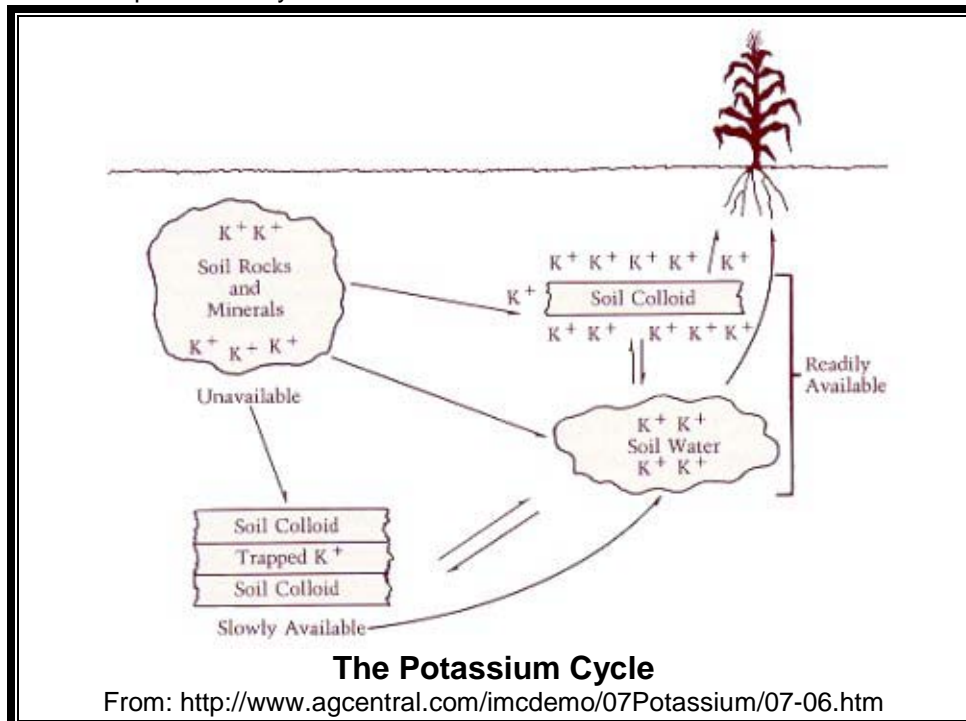
Potassium is essential for the movement of sugars within the plant and for starch formation. It is necessary for the opening and closing of stomata by guard cells, controlling water use by the plant. It encourages root growth and helps build disease resistance. It is involved with photosynthesis and enzyme activity. It helps regulate metabolic activity and is involved in protein synthesis. Potassium promotes larger and better quality fruits and grains. In some plants, more potassium is required than any other nutrient

2. Soil nutrient deficiencies, imbalances, toxicity

Potassium deficiency symptoms include:

- Slow growth
- Tip and marginal "burn" starting on more mature leaves. As severity of the deficiency increases, this condition progresses toward the top of the plant.
- Weak stalks, plants lodge easily
- Small fruit or shriveled fruit and seeds
- Reduced disease and pest resistance
- Increased sensitivity to drought, frost and salts
- White or yellow spots develop along the edges of clover leaves, in severe cases these join to give a scorched appearance.
- Excess potassium can cause:
 - Magnesium deficiency
 - Calcium deficiency in acid soils.

3. The potassium cycle



4. Potassium in soils factors affecting its availability

Plants take up potassium in the form of potassium ions (K^+). They may take up potassium that is adsorbed onto exchange sites (exchangeable K) or potassium that is dissolved in the soil solution. Consequently, in dry areas (where there is less soil solution) exchangeable K tends to be more important than dissolved K. Because K dissolves readily, it is highly mobile in the soil. However it can get trapped between layers of expanding clays. Potassium tends to remain in ionic form within cells and tissues.

Potassium is present in feldspars and is released upon weathering of the minerals. Soils formed from feldspar rich materials (such as granite or granitic alluvium) have a large supply of potassium to draw from. Even though a soil test may not show much potassium in such soils, it is usually released in sufficient quantities for plant growth. (Since much of the Sierras and southern California mountains are granitic, soils formed in these areas or in alluvium from these areas tend to have sufficient potassium.)

5. Potassium in amendments

Potential sources of potassium include wood ashes, granite dust, seaweed, greensand and langbeinite (Sulfate of Potash-Magnesia or Sul-Po-Mag). Greensand and langbeinite are non-renewable resources. Granite dust is also non-renewable, but granite occurs in such huge quantities over such extensive areas that using it should not be an issue. Wood ashes may increase the soil pH to undesirable levels and may not be available in large enough quantities.

Potassium in organic residues tends to be more highly available than that supplied by inorganic sources. So even though the total quantity of potassium supplied by these residues may be less, it may be more effective. With a steady program or recycling these residues, K is not likely to be deficient. Usually if the C:N ratio is high, the K:N ratio is also high.

f. Other macronutrients: Calcium, Magnesium, Sulfur

1. Calcium (Ca)

Plants take up calcium in its ionic form (Ca^{2+}). Calcium is an essential part of cell wall structure and it must be present for the formation of new cells both in the tops and in the roots. Calcium also helps control movement into and out of cells. It also reacts with waste products precipitating them or chelating them to render them harmless to the plant.

Calcium is normally so abundant that it usually only needs to be added to very acid soils where lime is required. However, excessive irrigation can leach calcium from the soil in sufficient quantities to bring about deficiency symptoms in plants. Plant roots are relatively inefficient at taking up calcium from the soil so the amount extracted is usually small compared to what is in the soil. Excess calcium can lead to a deficiency of magnesium or potassium.

Sources of Calcium include poultry manure, wood ashes, seashells, lobster shells, legume hay (which has no liming value), limestone and gypsum.

Calcium is not mobile in plants. Young tissue is first affected when there is a deficiency. Deficiency symptoms include:

- Death of growing points (terminal points) on plants. Root tips are also affected.
- Abnormal dark green appearance of foliage
- Premature shedding of blossoms and buds
- Weakened stems (causes cell membranes to lose permeability and disintegrate)
- "Blossom end rot" of tomatoes
- Short, thick, bulbous roots

2. Magnesium (Mg)

Plants take up magnesium in its ionic form (Mg^{2+}). Magnesium required for photosynthesis since it is contained in chlorophyll molecules. It helps in the assimilation of carbon dioxide during photosynthesis. Magnesium is also an activator for many plant enzymes required in growth processes. Magnesium is necessary for every operation that involves phosphorus in the plant and it also influences nitrogen metabolism.

Magnesium is generally available throughout the western states (where it is drier) but it is often more deficient than calcium. Magnesium, like calcium, is easily leached in humid areas. Soils

with low CEC's cannot hold much Mg. It is important to have a balance of magnesium, potassium and calcium so that no one of these elements dominate the cation exchange sites in the soil.

Sources of magnesium include plant residues, fresh poultry manure, dolomitic limestone and langbeinite (Sul-Po-Mag--see section on phosphorus),.

Magnesium is mobile within plants and can be translocated from older tissue to younger tissue during conditions of deficiency. Symptoms of magnesium deficiency include:

- Interveinal chlorosis (yellowing) in older leaves.
- Curling of leaves upward along margins.
- Marginal yellowing with green "Christmas tree" area along midrib of leaf.
- Stunted growth
- Ripe fruit is not sweet

3. Sulfur (S)

Plants take up sulfur in the form of the sulfate ion SO_4^{2-} . Sulfur is also sometimes absorbed from the air through leaves in industrial areas where sulfur is emitted into the atmosphere. Atmospheric sulfur can also come from volcanoes, sea spray and hydrogen sulfide (H_2S) emissions from swamps and oilfields.

As a constituent of three amino acids (cystine, methionine and cysteine), sulfur is very important for protein synthesis. Sulfur is also essential for nodule formation by nitrogen fixing bacteria on the roots of legumes. Sulfur is also present in oil compounds that give plants such as garlic and onions their characteristic odor.

The use of organic residues in amounts to satisfy other nutrient requirements will usually provide sufficient sulfur. Other sources of sulfur include animal manures (sulfur is usually well balanced with respect to nitrogen), langbeinite (Sul-Po-Mag--see section on phosphorus), gypsum and pure sulfur from natural sources (granular is preferred since sulfur dust is an explosion hazard).

Sulfur deficiency problems can occur if concentrated fertilizers for other nutrients are used that are free of sulfur.

Symptoms of sulfur deficiency include:

- Young leaves light green to yellowish in color. In some plants older tissue may be affected also.
- Small and spindly plants
- Retarded growth rate and delayed maturity
- Interveinal chlorosis on corn leaves

g. **Micronutrients:**

1. Introduction

Micronutrients are those plant nutrients that are needed only in small quantities compared to other (macro-) nutrients. This fact, however, does not diminish their importance. The effects of micronutrients on plants are difficult to understand, partly because of their interrelationships with each other and partly due to how the plants respond to micronutrients individually.

The response of many plants to micronutrients is almost an all or nothing affair. As long as the concentration of the micronutrients falls within a certain range, the response of the plant is the same, regardless of the exact concentration of the nutrient. If the concentration of the nutrient falls above this range, toxicity problems occur and if the concentration is below the range, the plants become deficient in the nutrient.

Interrelationships of micronutrients are many. For example, nitrogen fertilization can cause a deficiency of iron or copper. Prolonged phosphorus fertilization can lead to an iron deficiency. Excess phosphorus can lead to manganese deficiency. Sulfur and copper can cause molybdenum deficiencies, while the availability of molybdenum is increased by phosphorus. Iron, copper, manganese and zinc compete with each other.

Availability of micronutrients is highly dependent on soil pH and organic matter. At certain pHs, micronutrients can get bound to inorganic compounds and become unavailable. Organic matter can diminish the effect of pH. If micronutrient levels become too low, organic matter can often supply them. Copper, iron, manganese and zinc can get bound to soluble organic compounds that

are readily available to plants. These are called chelates. If micronutrient levels get too high, organic matter can bind them up so they don't become toxic.

2. **Boron** ($B_4O_7^{2-}$)

Boron is required in minute quantities by plants, but in spite of this, there may not be sufficient boron in some soils. Boron can also become toxic in amounts not much higher than that needed by the plants. Boron toxicity is most frequently a problem in soils formed at the bottoms of enclosed basins in arid areas where groundwater evaporates through the soil leaving salt concentrations near the surface (playas). Boron is needed for protein synthesis; for starch and sugar transport; to regulate nitrogen and carbohydrate metabolism; for root development and fruit and seed formation; for differentiation of meristem cells and for water uptake and transport. Boron contributes more than any other micronutrient to the quality of produce. Boron is non-mobile in plants and so a continuous supply is necessary at all growing points.

Symptoms of boron deficiency include:

- Death of terminal growth, causing lateral buds to develop and producing a "witches'-broom" effect
- Thickened, curled, wilted and chlorotic leaves
- Soft or necrotic spots in fruit or tubers
- Reduced flowering or improper pollination

3. **Copper** (Cu^{2+}),

Copper occurs as impurities in crystal structures of clays and other minerals. It may also occur in other compounds in the soil. As these materials weather the copper is released, after which it is adsorbed onto exchange sites from where it may be taken up by plants or leached from the soil. Consequently, soils formed from highly weathered materials may be deficient in copper. Copper is fairly abundant and deficiencies rarely occur. Also, since copper can be highly toxic at low levels, amendments should not be used except where the need for it has been established.

Copper is a catalyst for respiration and an activator of several enzymes. It is important for carbohydrate and protein synthesis. It may also play a role in carotene production.

Symptoms of copper deficiency include:

- Stunted growth
- Dieback of terminal shoots in trees
- Poor pigmentation
- Wilting and eventual death of leaf tips
- Formation of gum pockets around central pith in oranges

4. **Iron** (Fe^{2+} , Fe^{3+})

Plants require iron in larger amounts than any other micronutrient. It is used in chlorophyll synthesis; in oxidation-reduction during respiration, and as a constituent of various enzymes and proteins. It also serves as an activator for nitrogen fixation.

Iron is a very abundant in the soil, but some of its forms are so insoluble that plants may suffer a deficiency in spite of its abundance. (Like being stranded in the ocean and being thirsty for want of fresh water.) This is particularly true at pH's above 7; where there is a high content of lime or manganese; or where there is poor aeration (though Fe requires some period where oxygen is lacking). Some plants, such as peppers, are more susceptible than others are. Treatment may consist of adding iron in a form that won't be bound up in the soil or by lowering the pH.

Symptoms of iron deficiency include:

- interveinal chlorosis--a yellowing of the leaves between the veins
- twig dieback
- death of entire limbs or plants

5. **Manganese** (Mn^{2+})

Manganese is used in the metabolism of nitrogen and inorganic acids; for the formation of vitamins (carotene, riboflavin and ascorbic acid); for the assimilation of carbon dioxide during photosynthesis; and in the breakdown of carbohydrates. Manganese may be oxidized in the soil to form MnO_4^- . *High manganese levels may induce iron deficiency.*

Symptoms of manganese deficiency include:

- Interveinal chlorosis of young leaves. Gradation of pale green coloration with darker color next to veins. No sharp distinction between veins and interveinal areas as with iron deficiency.
- Development of gray specks (oats), interveinal white streaks (wheat) or interveinal brown spots and streaks (barley).

6. **Molybdenum** (MoO_4^{2-})

As with boron, molybdenum is needed only in minute quantities. Molybdenum is needed for nitrogen fixation and for reducing nitrate nitrogen to the amine form (plants take up nitrate- NO_3 but use it to create amines- NH_2 for amino acids). Because of this a molybdenum deficiency can cause a nitrogen deficiency in plants. Molybdenum has been found in quantities sufficient to be toxic to livestock in forage grown in inland desert areas such as the San Joaquin Valley and Nevada. Molybdenum levels tend to be low in highly leached soils.

Symptoms of molybdenum deficiency include:

- Stunting and lack of vigor (induced nitrogen deficiency)
- Marginal scorching and cupping or rolling of leaves
- "Whiptail" of cauliflower
- Yellow spotting of citrus

7. **Zinc** (Zn^{2+})

Zinc occurs as impurities in crystal structured and in other compounds in the soil. As it is released by weathering, it is adsorbed onto exchange sites from where it may be taken up by plants or leached from the soil. Consequently, soils formed from highly weathered materials (such as quartz and sandstone) may be deficient. Soils formed from igneous rocks tend to have higher levels of zinc. Zinc is used in the formation of growth hormones; for protein synthesis; and in seed and grain maturation and production.

A well-aerated soil is necessary for zinc availability.

Symptoms of zinc deficiency include:

- Decrease in stem length and a rosetting of terminal leaves
- Reduced fruit bud formation
- Mottled leaves (interveinal chlorosis)
- Dieback of twigs after first year
- Striping or banding on corn leaves

8. **Cobalt** (Co^{2+})

Cobalt occurs as impurities in crystal structured and in other compounds in the soil. As it is released by weathering, it is adsorbed onto exchange sites from where it may be taken up by plants or leached from the soil. Consequently, soils formed from highly weathered materials may be deficient. Cobalt has not yet been shown to be essential to higher plants, but it is essential in the symbiotic relationship between legumes and Rhizobia.

9. **Chlorine** (Cl)

Minute amounts of chlorine are essential to some plants. Even touching plants with sweaty hands may be sufficient to provide sufficient chloride. Chlorine is required for photosynthetic reactions in plants. However, the quantities needed are so small and chlorine is so abundant that deficiencies never occur in nature.

Symptoms of chlorine deficiency include:

- Wilting, followed by chlorosis
- Excessive branching of lateral roots
- Bronzing of leaves
- Chlorosis and necrosis in tomatoes and barley

10. **Others**

Other micronutrients that may be of importance are:

- a) silicon

Silicon gives plants mechanical strength and may help minimize water loss and increase disease resistance.

b) vanadium

Vanadium is not used directly by plants but seems to be required by soil organisms, which, in turn, benefit the plants.

c) Selenium, iodine and chromium

These elements are important to human and animal health. If they are present in the soil they can be taken up by plants and become available to plant consumers.

XIV. References and Resources

a. Institutions

Cooperative Extension Service or Farm Advisors office.

These folks will be aware of crop nutrient needs and problems in your area. They can assist you with nutrient deficiency symptoms and known plant nutrition problems in your area.

Soil and plant tissue labs.

These labs can test your soil or crop for deficiencies. Some websites containing listings of laboratories:

<http://www.attra.org/attra-pub/soil-lab.html>

http://organicgardening.com/library/soil_test_labs.html

A & L Western Agricultural Labs; 1311 Woodland Ave., No. 1; Modesto, CA 95351; (209) 529-4080

California AgQuest Consulting; 4325 N. Golden State, #105; Fresno, CA 93722; 559-275-8095

California Growers Laboratory; 4630 W. Jennifer, Suite 104; Fresno, CA 93722 USA; 559-275-3377

D&D Agricultural Laboratory; 5750 E Shields Ave; Fresno, CA 93727; 559-348-1818

Dellavalle Laboratory; 1910 W McKinley Ave; Fresno, CA 93728; 559-233-6129

Fruit Growers Lab; 2500 Stagecoach Road; Stockton, CA 95215; 209-942-0181

Growers Testing Services; 1525-A E. Acequia Ave.; Visalia, CA 93292-6652; 559-732-8378

Mid-State Laboratory, LLC; 9410 West Placer Ave.; Visalia, CA 93291; 559-651-9044

Precision Agri Lab/Western Farm Service; 24730 Ave. 13; Madera, CA 93637; 559-661-6386

Valley Tech; 2120 South K Street; Tulare, CA 93274; 559-688-5684

USDA-NRCS Field Offices

Information about soils in your area can be obtained from NRCS field offices. They are usually listed in the US government pages of the phone book under US Department of Agriculture. They may also be listed as **USDA Service Center**. Some areas do not have NRCS offices but do have **Resource Conservation District** offices that can provide the same information.

b. Books

Soil Surveys. These can be obtained at NRCS offices. They are also present in many libraries.

Brady, N.C., 1974, *The Nature and Property of Soils*, 8th edition, Macmillan Publishing Co., Inc., New York. A good general soils text, used for introductory soils classes at universities. Might be too technical for some.

Brady, N.C., and Weil, R.R. 1999, *The Nature and Property of Soils*, 12th edition, Prentice-Hall, Inc., Upper Saddle River, New Jersey. This is the most recent edition; covers some new subject matter and has improved charts and graphs. A good general soils text, used for introductory soils classes at universities. Might be too technical for some.

Buol, S.W., Hole, F.D., McCracken, R.J. and Southard, R.J., 1997, *Soil Genesis and Classification*, 4th edition, Iowa State University Press, Ames, Iowa. College textbook used to teach soil classification.

California Fertilizer Association, 1985, *Western Fertilizer Handbook*, The Interstate Printers & Publishers, Inc., Danville, Illinois. This book contains general information about soils and more detailed information about plant nutrients and fertilizers. Some parts may be difficult to understand. Emphasis is on inorganic fertilizers. Newer editions are available.

Dixon, J.B. and Weed, S.B., editors, 1989, *Minerals in Soil Environments*, Soil Science Society of America, Madison, WI. Very technical reference on soil minerals. Only the most hardy go here.

- Donahue, R.L., Miller, R.W. and Shickluna, J.C., 1977, *Soils: An Introduction to Soils and Plant Growth*, Prentice-Hall, Inc., Englewood Cliffs, NJ. An introductory college soils text. Probably too difficult for some. Out of print.
- Dubbin, William, 2001, *Soils*, The Natural History Museum, London. Available from Iowa State University Press. Short overview of soil science. Easy to read and understand, lots of color photos.
- Foth, H.D., 1984, *Fundamentals of Soil Science*, John Wiley & Sons, New York.
- Gershuny, G., 1993, *Start with the Soil*, Rodale Press, Emmaus, Pennsylvania. A general book on soils and soil management geared toward organic gardeners. Easy to read and understand.**
- Hanson, B., Grattan, S.R., and Fulton, A., 1993, *Agricultural Salinity and Drainage*, University of California, Davis, California. An indispensable reference for anyone farming in an area where salinity might be a problem.
- Parnes, Robert, 1990, *Fertile Soil: A Grower's Guide to Organic and Inorganic Fertilizers*, agAccess, Davis, California. Probably the best reference here on plant nutrients, with good coverage of organic amendments. Some useful reference charts in the appendices.
- Soil Survey Division Staff, 1993, *Soil Survey Manual*, United States Department of Agriculture, Washington DC., U.S. Government Printing Office. This is the manual that Soil Scientists used to carry out soil survey work. The most definitive guide on how to describe the physical properties of soil. Available online at http://www.statlab.iastate.edu/soils/ssm/gen_cont.html.
- Soil Survey Staff, Natural Resources Conservation Service, 1999, *National Soil Survey Handbook*, title 430-VI, United States Department of Agriculture, Washington, D.C., U.S. Government Printing Office. Contains all the technical details about making soil surveys and entering soil properties into the National Soils Information System (NASIS). Available online at <http://www.statlab.iastate.edu/soils/nssh/>.
- Soil Survey Staff, Natural Resources Conservation Service, 1999, *Soil Taxonomy*, United States Department of Agriculture, Washington, D.C., U.S. Government Printing Office. The reference we use to classify soils. Highly technical, not much use for anyone but soil scientists. Available online at <http://www.statlab.iastate.edu/soils/nsdaf/>.
- Stell, E.P., 1998, *Secrets to Great Soil*, Storey Communications, Inc., Pownal, Vermont. An easy to read primer on soils, composting and basic gardening techniques. Lots of diagrams.**
- Tisdale, S.L. and Nelson, W.L., 1966, *Soil Fertility and Fertilizers*, Macmillan Publishing Co., Inc., New York. A mid-level college text on soil fertility. Probably too difficult for most people. Out of Print.
- Thompson, L.M. and Troeh, F.R., 1978, *Soils and Soil Fertility*, Mc-Graw-Hill Book Company, New York. A general soils text used in introductory soils classes. Might be too technical for some.

c. Websites

Soil Physical Properties and general soils:

California NRCS home page	http://www.ca.nrcs.usda.gov
National soils databases	http://www.statlab.iastate.edu/soils/nsdaf
Index of all USDA databases	http://www.ncg.nrcs.usda.gov/nsdi_node.html
Science of Soils online journal	http://link.springer.de/link/service/journals/10112/index.htm
Glossary of Soil Science Terms	http://www.soils.org/sssagloss/index.html
Education Links	http://nscss.org/teach.html

Nitrogen:

- <http://www.extension.umn.edu/distribution/cropsystems/DC3770.html>
- http://www.fifa.asn.au/public/soil_fertility/fifa_14.html
- <http://lawr.ucdavis.edu/classes/SSC111/lect11.html>
- <http://helios.bto.ed.ac.uk/bto/microbes/nitrogen.htm>

Phosphorus:

- <http://www.extension.umn.edu/distribution/cropsystems/DC6288.html>
- <http://www.extension.umn.edu/distribution/cropsystems/DC6795.html>
- <http://biology.rwc.uc.edu/HomePage/BWS/ChemII/Phos.html>
- http://www.fifa.asn.au/public/soil_fertility/fifa_13.html
- <http://lawr.ucdavis.edu/classes/SSC111/lect13.html>
- <http://ess1.ps.uci.edu/~reeburgh/fig4.html>
- <http://www.soil.ncsu.edu/sera17/publications/sera17-1/index.htm>

Potassium:

- http://www.fifa.asn.au/public/soil_fertility/fifa_11.html
- <http://www.extension.umn.edu/distribution/cropsystems/DC6794.html>

<http://www.agcentral.com/imcdemo/07Potassium/07-06.htm>

Sulfur:

http://www.fifa.asn.au/public/soil_fertility/fifa_12.html

<http://www.agcentral.com/imcdemo/08Secondary/08-04.htm>

Carbon:

<http://lawr.ucdavis.edu/classes/SSC111/lect10.html>

Calcium, pH and liming:

<http://www.statlab.iastate.edu/survey/SQL/pdf/08d3.pdf>

<http://www.psu.edu/ur/NEWS/news/liming.html>

Miscellaneous nutrients:

<http://www.agcentral.com/imcdemo/09Micronutrients/09-02.htm>

<http://www.agric.gov.ab.ca/agdex/500>

<http://interactive.usask.ca/skinteractive/modules/agriculture/soils/index.html>

http://edis.ifas.ufl.edu/BODY_MG091

<http://www.fifa.asn.au/public/publications.html>

http://eap.mcgill.ca/MagRack/COG/COGHandbook/COGHandbook_1_3.htm (Organic field crop handbook)

<http://www.agcentral.com/imcdemo/Contributors/Con-2.htm> (Page full of links to graphics and figures)

<http://www.uog.edu/soil/>

http://www2.hawaii.edu/~nvhue/sustain_ag/sustag895.html (Organically Acceptable Inputs to Improve Soil Fertility)

Deficiency Symptoms:

<http://www.uark.edu/depts/agronomy/purcell/nutrients2.html> (Mobile versus immobile nutrients in cotton)

http://www.penpages.psu.edu/penpages_reference/29401/29401166.html (text only)

<http://www.hortnet.co.nz/publications/guides/fertmanual/dguide1.htm> (good photos)

<http://www.public.iastate.edu/%7Erkillorn/nutrie%7E1.htm> (good photos)

XV.

**APPENDIX 1
ESTIMATING AVAILABLE WATER CAPACITY**

Determine AWC for
each layer
soil texture



Reduce AWC for
each layer
for gravel



Reduce AWC for
each layer
for salts



Calculate AWC for
entire soil

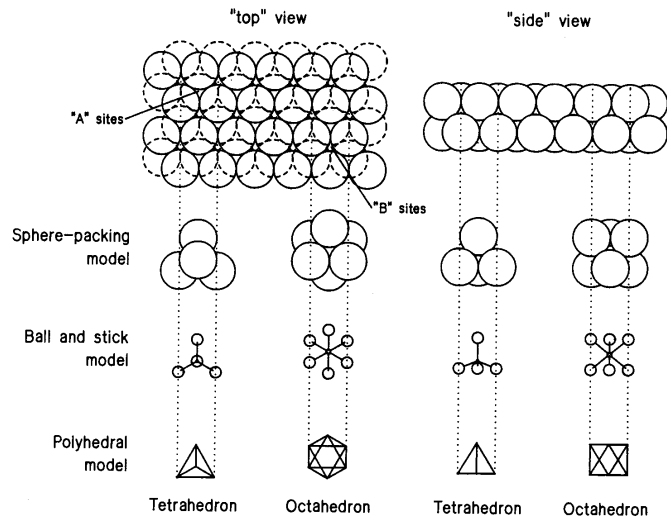
(In this example we assume no salts or coarse fragments)

Depth	Texture	Layer Thickness (ft.)	AWC Per Foot (in./ft.)	Available Moisture (in.)
0 to 8 inches	sandy loam	8/12 x	1.5 =	1.0
8 to 20 inches	sandy clay loam	12/12 x	1.9 =	1.9
20 to 48 inches	loamy sand	28/12 x	0.9 =	2.1
48 inches	rock (rooting depth)			
TOTAL AVAILABLE MOISTURE				5.0 inches

If you wanted to irrigate at 50% depletion, which is often the case, then in this case you would irrigate with 2.5 inches of water when the available water reached 2.5 inches (50% of 5 inches).

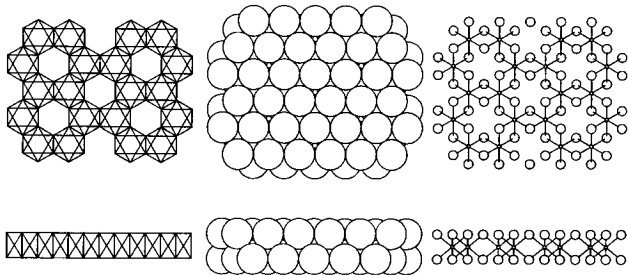
Example 1. Calculation of Total Available Water Capacity in the root zone

APPENDIX 2 DIAGRAM SHOWING TYPES OF MODELS USED TO SHOW CLAY MINERAL STRUCTURES

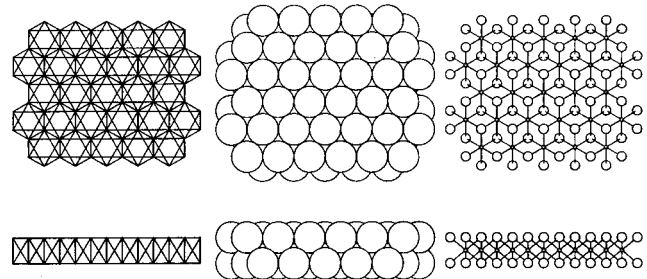


Types of lattice-clay sheets

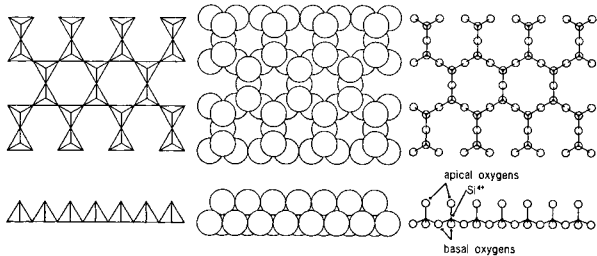
The Octahedral Sheet (dioctahedral)



The Octahedral Sheet (trioctahedral)

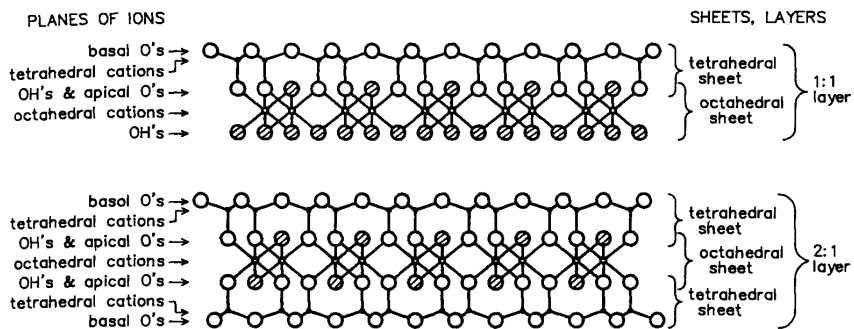


The Tetrahedral Sheet



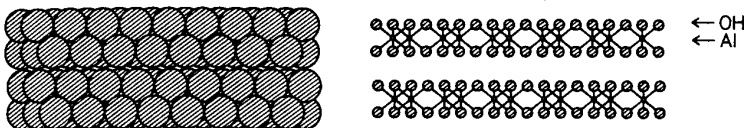
Diagrams on this page and the following page are from Schulze, D.G., 1989, *An Introduction to Soil Mineralogy in Minerals in Soil Environments*, Dixon, J.B. and Weed, S.B., editors, Soil Science Society of America.

APPENDIX 3 MODEL SHOWING ARRANGEMENT OF 1:1 and 2:1 SHEETS

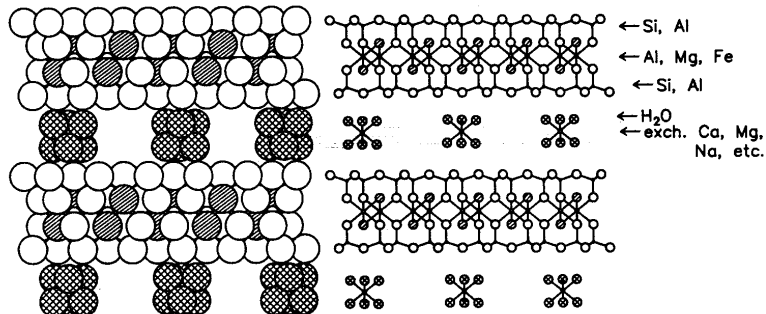


SPECIFIC CLAY MINERAL STRUCTURES

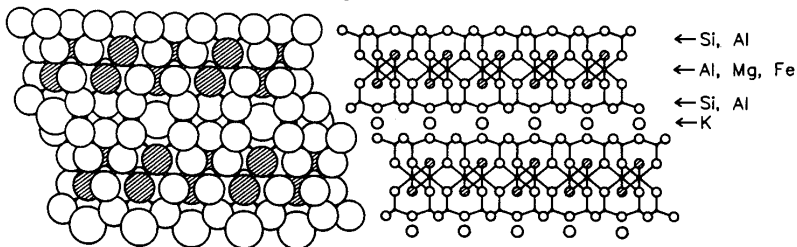
Gibbsite



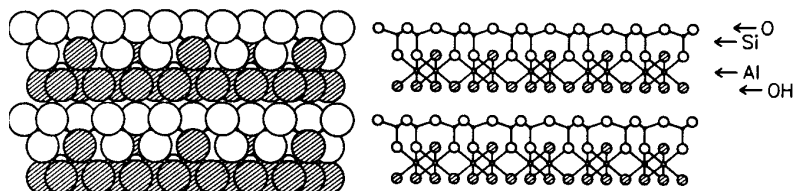
Vermiculite and Smectite



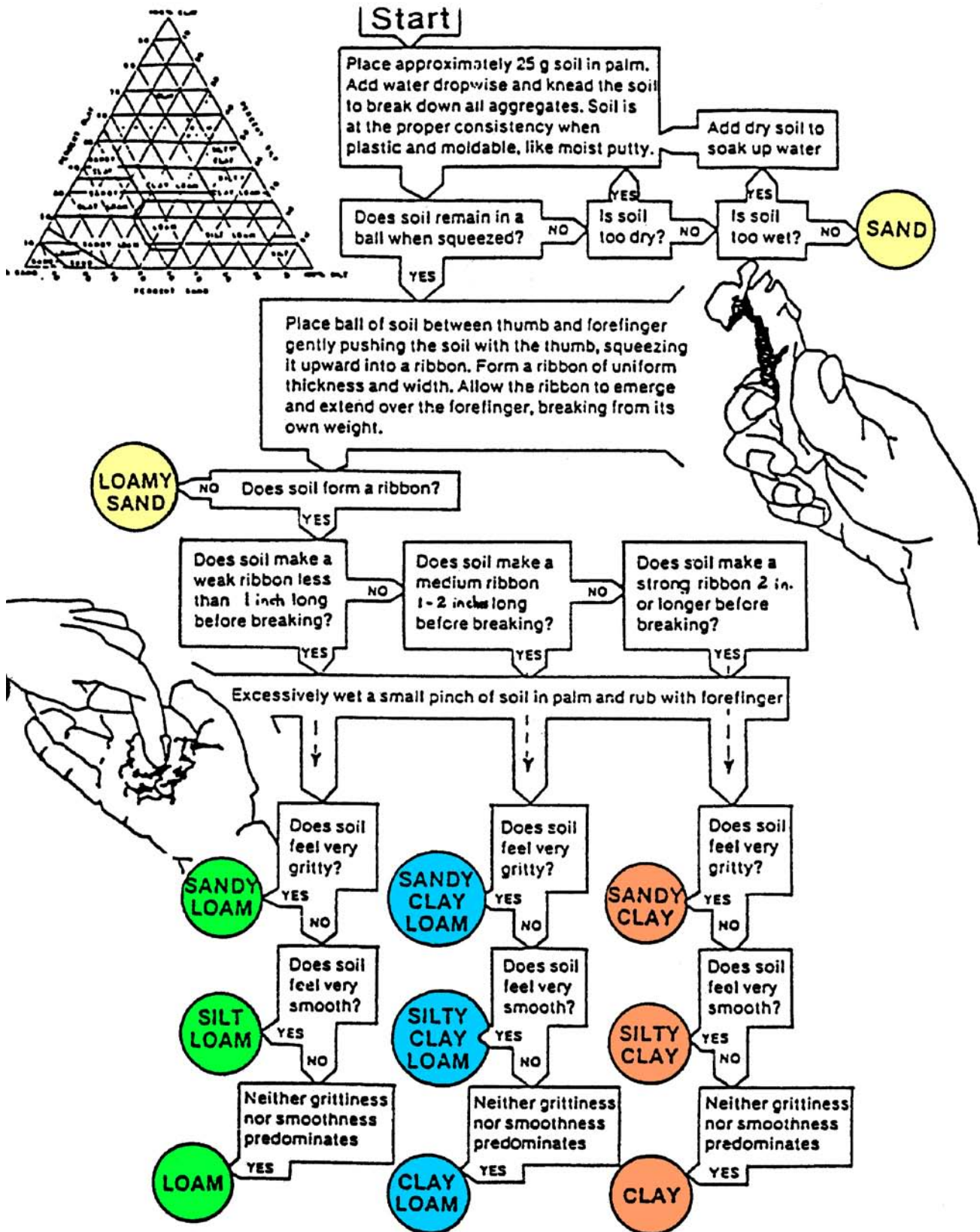
Mica



Kaolinite



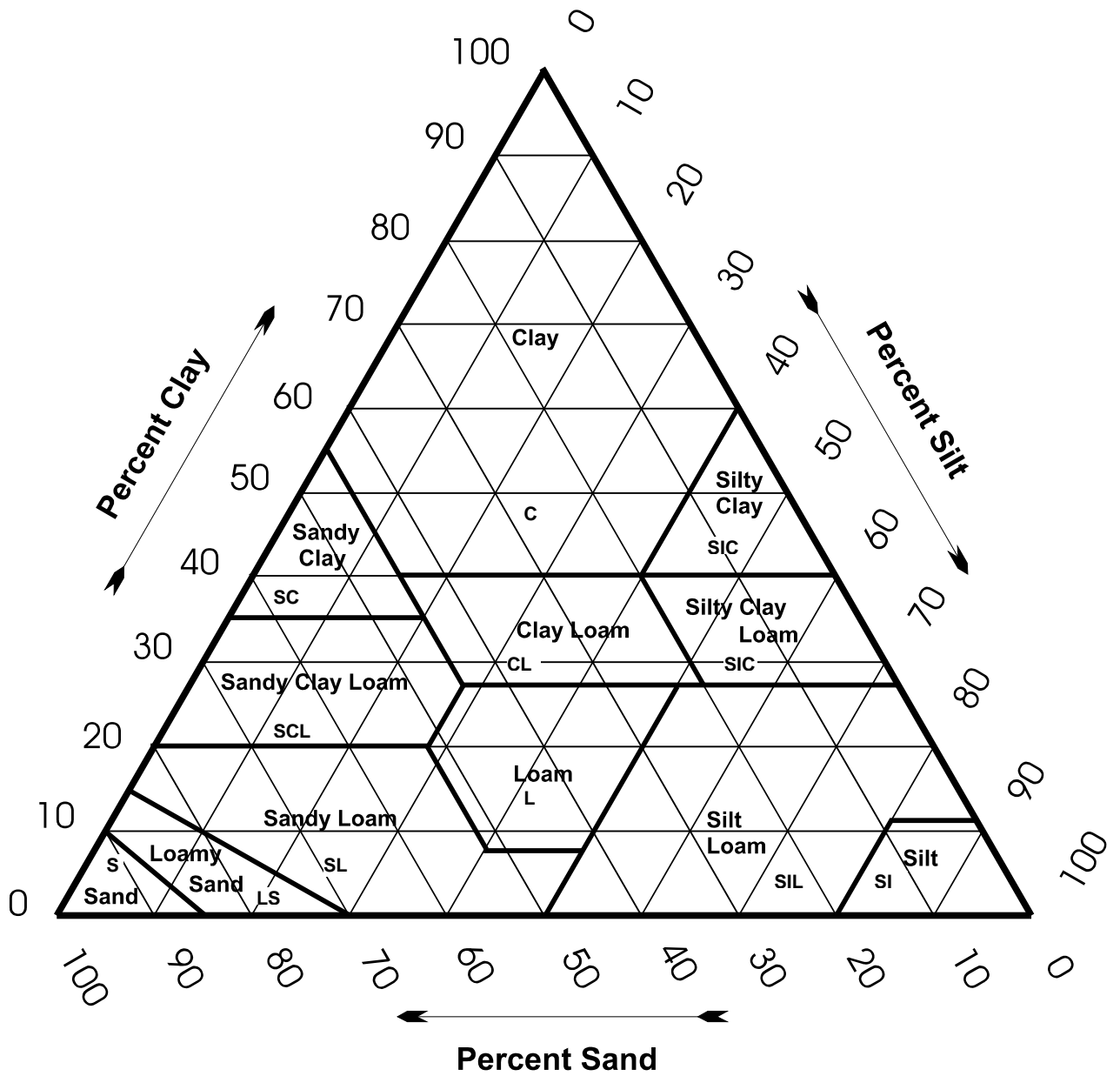
APPENDIX 4
GUIDE FOR DETERMINING SOIL TEXTURE BY FEEL



From: A Flow Diagram for Teaching Texture-by-Feel Analysis, by Steve J. Thien, Journal of Agronomic Education; Vol. 8, 1979, pp 54-55.

XIX.

APPENDIX 5 TEXTURE TRIANGLE



IRRIGATION

WHEN AND HOW MUCH?



Distributed
by
Interagency Agricultural
Information Task
Force

IRRIGATION – WHEN AND HOW MUCH?

When to irrigate and how much water to apply are the two most important questions to be answered when irrigating. This bulletin outlines guides and principles to answer these questions. Combine them with your own judgment and experience to improve your irrigation water management.

For more information on irrigation water management or for technical assistance on improving your system efficiency, contact your local representative of the Soil Conservation Service, University of California Cooperative Extension Service, Bureau of Reclamation, irrigation or resource conservation districts, Department of Water Resources Specialists, or irrigation consultants.

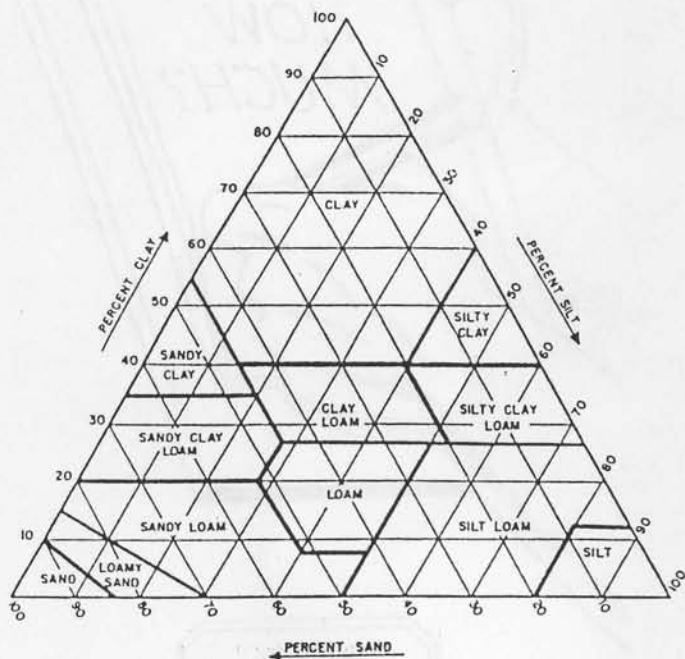


Figure 1 Soil Textural Classes

SOIL

The soil is a storehouse of plant nutrients, an anchorage for plants and a reservoir that holds the water needed for plant growth. The amount of water a soil can hold, available for plant use, is determined by the soil's physical properties. The soil texture (Figure 1) is probably the most influential factor in determining the Available Waterholding Capacity (AWC) of the soil. Many soils will have varying textures at different depths. Table 1 gives the general range of AWC per foot of depth for various soil textures. Soil textures for your fields can be found in your conservation plan developed by the Soil Conservation Service or, by consulting your local farm advisor, and specialists of the agencies mentioned above.

Table 1. Available Waterholding Capacity (AWC) for Various Soil Textures

	Available Moisture	
	Range In./Ft.	Average In./Ft.
Very Coarse to Coarse Textured Sand	0.5 – 1.25	0.90
Moderately Coarse Textured Sandy Loams and Fine Sandy Loams	1.25 – 1.75	1.50
Medium Texture - Very Fine Sandy Loams to Silty Clay Loam	1.50 – 2.30	1.90
Fine and Very Fine Texture - Silty Clay to Clay	1.60 – 2.50	2.10
Peats and Mucks	2.00 – 3.00	2.50

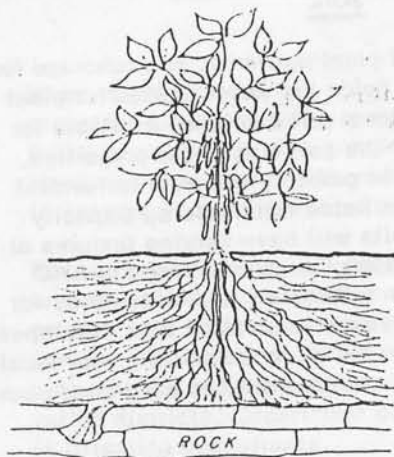


Figure 2

ROOTING DEPTH

The depth of soil from which your crop can extract water is the effective crop rooting depth. This depth will vary with the stage of crop growth. Rooting depth (Figure 2) may be restricted to a depth considerably less than the normal root depth by soil limitations (i.e., hardpan, high-water table, etc.). Normal rooting depths for several mature irrigated crops, grown on deep, permeable, well drained soil, are given in Table 2.

Table 2. Normal Crop Rooting Depths

Crop	Feet	Crop	Feet
Alfalfa	5-10	Grain	3-4
Artichokes	4	Grass Pasture	2-4
Asparagus	6-10	Hops	5-8
Beans	3-4	Ladino Clover	2
Beets (sugar)	4-6	Lettuce	6
Beets (table)	2-3	Melons	6
Broccoli	2	Onions	1
Cabbage	2	Peas	3-4
Bush berries	4-6	Peppers	2-3
Carrots	2-3	Potatoes (Irish)	3-4
Cauliflower	2	Pumpkins	6
Celery	3	Radishes	1
Citrus	4-6	Spinach	2
Corn (sweet)	3	Squash	3
Corn (field)	4-5	Strawberries	3-4
Deciduous orchards	6-8	Tomatoes	6-10
Garlic	1-2	Walnuts	12
Grapes	4-6		

TOTAL AVAILABLE MOISTURE

The total amount of water available for plant use in the root zone is the sum of the Available Waterholding Capacity per foot, for the various soil types within the effective rooting depth. See the example below.

Example 1. Calculation of Total Available Moisture in the Root Zone

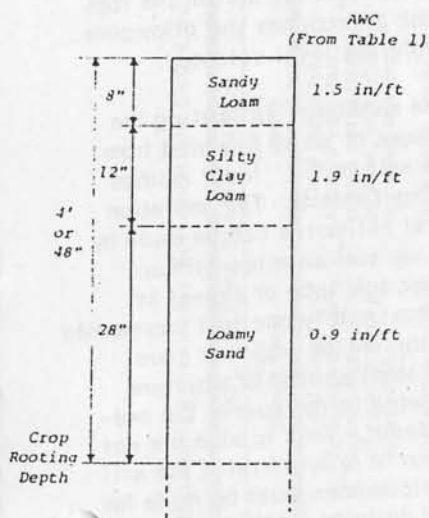


Figure 3

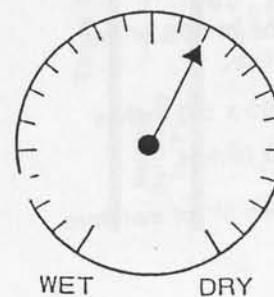
Assume the crop is beans with a 4 foot rooting depth (Table 2) and is grown in a soil (see Figure 3) with the following characteristics:

Depth	Layer Thickness (ft.)	AWC Per Foot (in/ft)	Available Moisture (in.)
0 to 8 Inches	$\frac{8}{12}$	$\times 1.5$	$= 1.0$
8 to 20 Inches	$\frac{12}{12}$	$\times 1.9$	$= 1.9$
20 to 48 Inches	$\frac{28}{12}$	$\times 0.9$	$= 2.1$

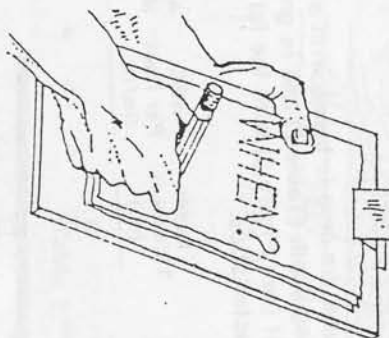
Total Available Moisture = 5.0 inches

ALLOWABLE MOISTURE DEPLETION

There is an economic optimum amount or level of soil moisture that should be depleted before irrigating. This point is often described as a portion or percent of the total available moisture in the root zone. There are many factors that should be considered in determining this allowable depletion level, the most important of which is the crop itself. Other factors such



as consumptive use rate, available water supply, salinity, drainage and labor should also be considered. Moisture depletion allowances usually vary from 30 to 70 percent. For guidance in selecting a depletion level for your crop and management situation consult your local farm advisor or Soil Conservation Service technician.



WHEN TO IRRIGATE

Irrigation should be scheduled when the amount of water depleted from the soil in the root zone approaches the allowable depletion level selected.

One method of estimating the amount of water depleted from the soil is the "feel" method using Table 3. The depletion level estimates can be made by taking soil samples with an auger, soil tube or shovel at approximately one-foot increments for the entire crop root zone. The total amount of moisture depleted is the sum of the one-foot increments for the crop rooting depth. This is also the net amount to be replaced by the irrigation in order to refill the soil profile to its capacity. Additional allowances must be made for deep percolation, tail-end losses and salinity leaching.

foot increments for the crop rooting depth. This is also the net amount to be replaced by the irrigation in order to refill the soil profile to its capacity. Additional allowances must be made for deep percolation, tail-end losses and salinity leaching.

Example 2. Estimating When to Irrigate

Assume the following:

The same soil and crop as in Example 1.

An allowable moisture depletion of 60% of the total available in the 4' root zone.

Allowable depletion level = 0.60×5.0 inches
= 3.0 inches

This means that irrigation should begin when 3" of moisture have been lost by this calculation.

Table 3. Guide for Estimating Available Soil Moisture Depleted by the "Feel" Method

Moisture Deficiency In./Ft.	SOIL TEXTURE CLASSIFICATION				Moisture Deficiency In./Ft.
	Coarse (loamy sand)	Sandy (sandy loam)	Medium (loam)	Fine (clay loam)	
.0	(field capacity) Leaves wet outline on hand when squeezed.	(field capacity) Appears very dark, leaves wet outline on hand, makes a short ribbon.	(field capacity) Appears very dark, leaves wet outline on hand, will ribbon out about one inch.	(field capacity) Appears very dark, leaves slight moisture on hand when squeezed, will ribbon out about two inches.	.0
.2	Appears moist, makes a weak ball.	Quite dark color, makes a hard ball.	Dark color, forms a plastic ball, slicks when rubbed.	Dark color, will slick and ribbons easily	.2
.4	Appears slightly moist sticks together slightly.	Fairly dark color, makes a good ball.	Quite dark, forms a hard ball.	Quite dark, will make thick ribbon, may slick when rubbed.	.4
.6	Dry, loose, flows thru fingers. (wilting point)	Slightly dark color, makes a weak ball.	Fairly dark, forms a good ball.	Fairly dark, makes a good ball.	.6
.8		Lightly colored by moisture, will not ball.	Slightly dark, forms weak ball.	Will ball, small clods will flatten out rather than crumble.	.8
1.0		Very slight color due to moisture. (wilting point)	Lightly colored, small clods crumble fairly easily.	Slightly dark, clods crumble.	1.0
1.2			Slight color due to moisture, small clods are hard. (wilting point)	Some darkness due to unavailable moisture, clods are hard, cracked. (wilting point)	1.2
1.4					1.4
1.6					1.6
1.8					1.8
2.0					2.0

Field Method of Approximating Soil Moisture for Irrigation. From Am. Soc. Agri. Engr. Vol. 3, No. 1, 1960, by John L. Merriam., California State Polytechnic College.

From soil texture samples shown in Example 1, and data from Table 3, the following soil moisture depletion was estimated:

Depth	Texture	Feel or Appearance	Moisture Depleted
0 - 1'	Sand Loam (sandy)	Very slight color due to moisture	1.2
1 - 2'	Silty Clay Loam (clay loam)	Fairly dark, makes a good ball	1.0
2 - 3'	Loamy Sand (Coarse)	Slightly moist, sticks together	0.5
3 - 4'	Loamy Sand (Coarse)	Appears moist, makes a weak ball	0.3
Total Moisture Depleted			3.0"

Since
and
Irrigation should begin immediately!

Moisture Depleted = 3"
Allowable Depletion = 3"

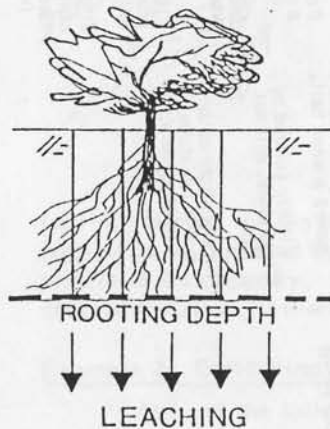


Figure 4

LEACHING REQUIREMENT

All irrigation water and soils contain some soluble salts. Plants use the water and most of the salts remain in the soil. If not removed periodically, the salts will accumulate to a point that is toxic to the plant.

Removal of the salts can be accomplished by applying additional water that will flush the salts out of or below the crop root zone (Figure 4). This can be done as part of your normal irrigation application or as a separate program. The amount

of water required to obtain a satisfactory salt balance in the crop root zone is called the leaching requirement (LR) and depends mainly on the amount of salt present in the soil, the irrigation water quality and the crop grown. IN DROUGHT YEARS LEACHING OF SALTS MAY BE TEMPORARILY POSTPONED. For more information and technical assistance in determining the leaching requirement for your field and crop, consult your local specialist.

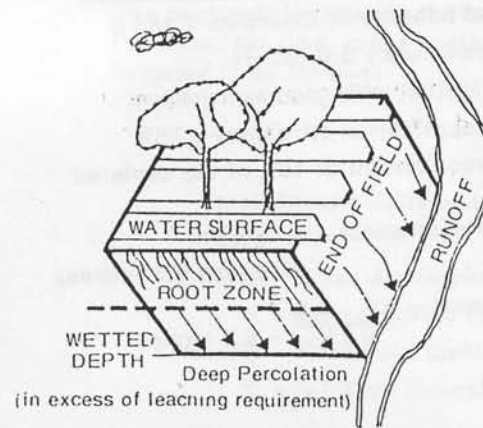


Figure 5. Wetted Soil Profile

APPLICATION EFFICIENCY

The application efficiency is an indication of the irrigation system's ability to deliver water according to plant needs. It involves the total amount of water applied, the uniformity of the distribution, losses such as runoff, evaporation and deep percolation and the net amount of water needed to meet plant growth requirements and leaching. It is a direct reflection of management practices and the irrigation system's capability.

Common application efficiencies for various types of irrigation systems, under good to excellent management, are listed in Table 4.

Table 4. Irrigation Application Efficiencies Under Good to Excellent Management

System	Approximate Range of Application Efficiencies
Furrow Basin	70 - 85%
Sprinklers	75 - 90%
Graded Border	70 - 85%
Drip (Trickle)	80 - 90%



HOW MUCH TO APPLY

The gross amount of water to be applied is the net amount required to refill the crop root zone (to meet plant requirements), plus the amount required for leaching (to maintain a satisfactory salt balance in the soil), divided by the application efficiency.

$$\text{Gross Application Required} = \frac{\text{Depleted Moisture to be Replaced} + \text{Leaching Requirement}}{\text{Application Efficiency}}$$

Example 3. Calculation of the Gross Application Required

Assume same conditions as in Examples 1 and 2

Depleted moisture = 3.0 inches

Assume furrow irrigation with good management

Estimated application efficiency = 75%

Assume leaching requirement of 15% of the depleted moisture

Leaching Requirement = 0.15×3.0
= 0.45 (use 0.5 inches)

Gross application requirement = $\frac{3.0 + 0.5}{0.75} = 4.7$ inches

MANAGEMENT

So far, the discussion has assumed flexibility in the scheduling of irrigation and the total amount applied. An irrigation is scheduled when the amount of soil moisture depleted from the root zone approaches the allowable depletion level. The amount of water applied is based on replacing the depleted soil moisture. This involves decisions for both when to irrigate and how much to apply. This allows optimum moisture conditions for crop production and minimizes irrigation costs.



Occasionally water deliveries are on a fixed schedule when deliveries are made every 10 to 15 days. Under these conditions it is not necessary to decide when to irrigate but only how much to apply. The amount applied then should be based only on the soil moisture depleted since the last irrigation.

The relationship between the total amount delivered, delivery flow rate, set time, gross application and the area to be irrigated is as follows:

$$\text{Total Amount Delivered} = D \times A = Q \times T$$

Where,

D = Cross Application Depth (inches)

A = Area Irrigated (acres)

Q = Flow Rate (cubic feet per second, cfs)

T = Set Time (hours)

This equation can be used to calculate ¹ gross application DEPTH applied, ² the AREA to be irrigated, ³ the FLOW rate (Q) required, and, ⁴ the set or delivery TIME. (See Reference 3.)

When the flow rate, time of set and area irrigated are known, the gross application depth (D) can be calculated by:

$$D = \frac{Q \times T}{A}$$

When the flow rate, the set time and the gross application depth are known, then the area that can be irrigated (A) can be calculated by:

$$A = \frac{Q \times T}{D}$$

When the gross application depth, the set time and the area irrigated are known, then the flow rate (Q) needed can be calculated from:

$$Q = \frac{D \times A}{T}$$

When the gross application depth, the flow rate and the area to be irrigated are known, then the set time (T) can be calculated from:

$$T = \frac{D \times A}{Q}$$

Example 4. Calculating the Required Flow Rate

Assume information from previous examples

Gross application = 4.7 inches

Assume 5 acres irrigated per set

Assume a set time of 10 hours

$$\begin{aligned}\text{Required Flow Rate (Q)} &= \frac{D \times A}{T} \\ &= \frac{(4.7) \times (5.0)}{10} \\ &= 2.35 \text{ cfs} \\ &= 1055 \text{ gallons per minute}\end{aligned}$$

FOR FURTHER INFORMATION CONTACT:

Agricultural Research Service
Department of Water Resources
Soil Conservation Service
State Water Resources Control Board
University of California
U.S. Bureau of Reclamation
U.S. Geological Survey

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4. Irrigation System Evaluation and Improvement, John L. Merriam et al, Utah Water Research Laboratory, Utah State University, Logan, Utah, (1973)
5. A Management Control Concept for Determining the Economical Depth and Frequency of Irrigation, John L. Merriam, Transactions of the American Society of Agricultural Engineers, (1966)

NRCS General Crop Water Requirements Placer County

Crop	Planting Month	Planting Day	Harvest Month	Harvest Day	Max Etc in/day	Yearly ETC inches	4/15 to 10/15 Season inches	100% Efficiency		70% Efficiency		50% Efficiency	
								gpm / acre	miners in. / acre	gpm / acre	miners in. / acre	gpm / acre	miners in. / acre
(ETo, Reference ET)	1	1	12	31	0.30	55	41	5.7	0.5	8.1	0.7	11.4	0.7
Alfalfa (annual)	3	15	10	15	0.30	45	41	5.7	0.5	8.1	0.7	11.4	0.7
Almonds	3	1	10	15	0.32	44	40	6.0	0.5	8.6	0.8	12.0	0.7
Apple	4	1	11	15	0.30	42	38	5.8	0.5	8.2	0.7	11.5	0.7
Citrus	1	1	12	31	0.20	37	27	3.8	0.3	5.5	0.5	7.6	0.5
Corn (grain)	5	1	9	30	0.33	28	28	6.3	0.6	9.0	0.8	12.5	0.7
Evergreen	1	1	12	31	0.18	33	24	3.4	0.3	4.9	0.4	6.8	0.4
Grapevines	4	1	11	1	0.24	33	31	4.6	0.4	6.5	0.6	9.1	0.5
Kiwifruit	5	1	10	31	0.33	41	39	6.3	0.6	9.0	0.8	12.5	0.7
Pasture	1	1	12	31	0.30	55	41	5.7	0.5	8.1	0.7	11.4	0.7
Rice	5	13	10	31	0.33	41	42	6.3	0.6	9.0	0.8	12.5	0.7
Sorghum	5	13	9	29	0.33	27	27	6.3	0.6	9.0	0.8	12.5	0.7
Stone fruits	3	1	10	15	0.32	44	40	6.0	0.5	8.6	0.8	12.0	0.7
Strawberries	5	1	9	30	0.21	20	20	4.0	0.4	5.7	0.5	8.0	0.5
Tomato	5	1	9	15	0.35	27	30	6.6	0.6	9.4	0.8	13.1	0.8
Walnuts	4	1	11	15	0.30	42	38	5.8	0.5	8.2	0.7	11.5	0.7
(ETo, Reference ET)	1	1	12	31	0.29	57	41	5.5	0.5	7.8	0.7	10.9	0.6
Alfalfa (annual)	3	15	10	15	0.29	46	41	5.5	0.5	7.8	0.7	10.9	0.6
Almonds	3	1	10	15	0.30	45	40	5.7	0.5	8.2	0.7	11.4	0.7
Apple	4	1	11	15	0.29	42	38	5.5	0.5	7.9	0.7	11.0	0.7
Citrus	1	1	12	31	0.19	38	27	3.7	0.3	5.2	0.5	7.3	0.4
Corn (grain)	5	1	9	30	0.32	27.77	28	6.0	0.5	8.6	0.8	12.0	0.7
Evergreen	1	1	12	31	0.17	34.34	25	3.3	0.3	4.7	0.4	6.5	0.4
Grapevines	4	1	11	1	0.23	33.21	31	4.4	0.4	6.2	0.6	8.7	0.5
Kiwifruit	5	1	10	31	0.32	40.83	39	6.0	0.5	8.6	0.8	12.0	0.7
Pasture	1	1	12	31	0.29	57.24	41	5.5	0.5	7.8	0.7	10.9	0.6
Rice	5	13	10	31	0.32	41.23	42	6.0	0.5	8.6	0.8	12.0	0.7
Sorghum	5	13	9	29	0.32	26.24	27	6.0	0.5	8.6	0.8	12.0	0.7
Stone fruits	3	1	10	15	0.30	44.63	40	5.7	0.5	8.2	0.7	11.4	0.7
Strawberries	5	1	9	30	0.20	20.08	20	3.8	0.3	5.5	0.5	7.6	0.5
Tomato	5	1	9	15	0.33	27.52	30	6.2	0.6	9.0	0.8	12.5	0.7
Walnuts	4	1	11	15	0.29	42.43	38	5.5	0.5	7.9	0.7	11.0	0.7

Soil Management and Soil Quality for Organic Crops

(Merge protected. Find at: <http://ucanr.org/freepubs/docs/7248.pdf>)

Soil Management and Soil Quality for Organic Crops (Jeff Mitchell, Mark Gaskell, Richard Smith, Calvin Fouche, & Steven T Koike, University of California Division of Agriculture and Natural Resources, 2000, Publication 7248)

COVER CROPS FOR THE SIERRA NEVADA FOOTHILLS

Publication
Number
31-071C
(revised Oct. 2006)

AUTHORS: Cindy Fake, Horticulture and Small Farms Advisor, Nevada & Placer Counties, James Dumas, Sierra College Intern.

Cover crops are an critical component of most foothill cropping systems. They are important in maintaining soil fertility, retaining water and preventing soil erosion in our high rainfall climate. They may also play a role in pest management.

Why Use Cover Crops?

1. Soil fertility

- Legume cover crops can fix 70 to 250 lbs/acre of nitrogen, depending on species.
- As cover crop plants decay, provide N and other nutrients.
- Grass cover crops can capture applied nitrogen and reduce leaching.
- Deep-rooted cover crops may extract nutrients from the subsoil and deposit them in upper soil layers, making them more available to crop plants.
- Some may increase phosphorous or calcium availability.

2. Increase soil organic matter

- Cover crop roots enhance soil microbial growth.
- Microbes produce substances that contribute to soil aggregation, which can improve water infiltration.

3. Improve soil structure

- Improve soil aggregation and

friability (ability to break up)

- Improve soil tilth (workability).

4. Reduce soil erosion

- Vegetative cover reduces impact of rain droplets.
- Plant roots stabilize soil and reduce erosion on slopes and fragile soils.

5. Improve water infiltration or water holding capacity

- Increased organic matter increases pore space, especially in heavy clay soils.
- Increased organic matter acts like a sponge to hold water in sandy soils.
- Roots create tiny channels for water infiltration.

6. Provide weed control

- Cover crops may suppress weed growth between tree and vine rows.
- Cover crops may outcompete some weeds such as Bermuda grass, puncture vine, purslane, nutsedge, yellow starthistle and others.

7. Manage nutrients

8. Mulch

9. Provide habitat for natural enemies

10. Allow growers to get into field earlier in the spring and provide better traction.

11. Improvement in fruit quality – winegrapes

- Cover crops can be used to reduce vine vigor.
- Grasses may reduce soil N on vigorous sites.
- Cover crops reduce soil moisture in spring so may slightly stress vine, improving fruit quality.

In the foothills, controlling topsoil erosion is key advantage of cover crops.

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Cover Cropping in Vineyards.

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Managing Cover Crops Profitably.

1998. Sustainable Agriculture Network. Beltsville, Maryland.

UC SAREP Covercrop Resource

page. <http://www.sarep.ucdavis.edu/ccrop/>



COOPERATIVE EXTENSION, UNIVERSITY OF CALIFORNIA

Placer County

WEB SITE: ceplacervevada.ucdavis.edu

Nevada County



11477 E Avenue (Bldg 306, DeWitt Center)
Auburn, California 95603
(530) 889-7385
FAX (530) 889-7397
E-Mail: ceplacer@ucdavis.edu

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United States Department of Agriculture, University of California, Placer and Nevada Counties cooperating.

255 So Auburn (Veterans Memorial Bldg)
Grass Valley, California 95945
(530) 273-4563
FAX (530) 273-4769
E-Mail: cenevada@ucdavis.edu

Cover Crop Species	Nitrogen Source	Reduces vigor, uses N	Organic Matter	Erosion Control	Weed Control	Natural Enemies	Quick Growth	Loosens Soil	Height	Type	Hardy thru USDA Zone
Legumes											
Berseem Clover <i>Trifolium alexandrinum</i>	4	3	3	3	4	2	4	3	2'	WA	8
Crimson Clover <i>Trifolium incarnatum</i>	3	2	3	3	3	3	1	2	12-20"	WA, SA	7
Subterranean Clover <i>Trifolium subterraneum</i>	4	1	3	3	4	3	2	2	6-15"	CSA	7
Strawberry Clover <i>Trifolium fragiferum</i>	4	1	2	4	3	2	2	2	8-12"	P	7
White Clover <i>Trifolium repens</i>	4	1	2	3	3	2	1	3	8-12"	P, WA	4
Medics <i>Medicago spp.</i>	2	1	2	2	3	1	4	1	12-18"	SA	4-7
Austrian Winter Pea <i>Pisum sativum ssp. arvense</i>	4	1	3	3	2	3	3	3	3'	WA	7
Miranda Pea <i>Pisum sativum 'Miranda'</i>	4	1	2	3	2	3	4	3	3'	WA	7
Woolypod Vetch <i>Vicia villosa ssp. dasycarpa 'Lana'</i>	4	2	4	2	4	3	3	3	18-24 "	CSA	7
Bell Bean <i>Vicia faba</i>	3	1	4	2	2	4	3	3	8'	WA, SA	8
Grasses											
Barley <i>Hordeum vulgare</i>		3	3	4	3	2	3	3	24-36"	WA	7
Blando Brome <i>Bromus mollis</i>		2	2	4	3	2	3	3	2'	CSA	6
Foxtail (Zorro) Fescue <i>Vulpia myuros var. myuros</i>		3	2	4	3	0	4	4	12-24"	WA	7
Oats <i>Avena sativa 'Cayuse'</i>		3	2	3	4	0	4	3	5'	CSA	8
Perennial Ryegrass <i>Lolium perenne</i>		2	3	3	3	1	2	4	3-4'	P	7
Annual Ryegrass <i>Lolium multiflorum</i>		3	4	4	3	1	3	4	36-48"	WA	6
Rye <i>Secale cereale</i>		4	4	4	4	1	4	4	36-72"	CSA	3
Triticale <i>Triticum x Secale</i>		3	3	4	3	1	3	3	24-60"	WA	7
Winter Wheat <i>Triticum aestivum</i>		3	3	3	3	1	2	3	24-40"	WA	4
White Mustard <i>Brassica hirta</i>		3	4	3	3	4	3	4	4'	WA	7

0: Poor, 1: Fair, 2: Good, 3: Very Good, 4: Excellent. CSA: Cool Season Annual, WA: Winter Annual SA: Summer Annual, P: Perennial

Soil Fertility Management for Organic Crops

(Merge protected. Find at: <http://ucanr.org/freepubs/docs/7249.pdf>)

Soil Fertility Management for Organic Crops (Mark Gaskell, Richard Smith, Jeff Mitchell, Steven T Koike, Calvin Fouche, Tim Hartz, William Horwath & Louise Jackson, University of California Division of Agriculture and Natural Resources, April 2007, Publication 7249)

OVERVIEW OF COVER CROPS AND GREEN MANURES

FUNDAMENTALS OF SUSTAINABLE AGRICULTURE

Abstract: *Cover crops could be considered the backbone of any annual cropping system that seeks to be sustainable. In this publication we summarize the principal uses and benefits of cover crops and green manures. Brief descriptions and examples are provided for winter cover crops, summer green manures, living mulches, catch crops, and some forage crops. To impart a sense of the importance of these practices in sustainable farming, we summarize the effect of cover crops and green manures on: organic matter and soil structure, nitrogen production, soil microbial activity, nutrient enhancement, rooting action, weed suppression, and soil and water conservation. Management issues addressed include vegetation management, limitations of cover crops, use in crop rotations, use in pest management, and economics of cover crops. A selection of print and Web resources are provided for further reading.*

By **Preston Sullivan**
NCAT Agriculture Specialist
July 2003

Introduction

Cover crop information abounds. In the past ten years, the number of research reports, Extension bulletins, Experiment Station reports, and popular press articles on cover crops has increased dramatically. For example, the third quarter 1998 issue of *The Journal of Soil and Water Conservation* contains 17 research reports on cover crops. Several excellent field handbooks have also been written. Consequently, rather than attempting to address that large body of information, this publication serves as an overview of cover crops and their uses and provides a resource list. The resource list gives ordering instructions and prices for readers who want current information in more detail.

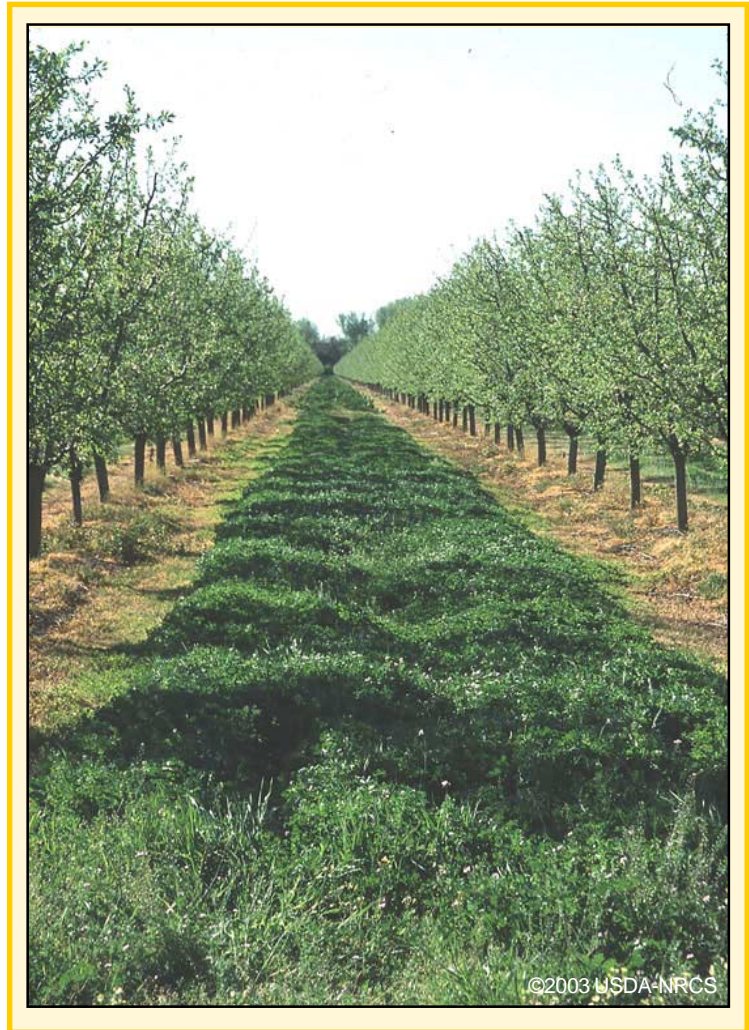


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Principal Uses of Cover Crops and Green Manures

“Green manuring” involves the soil incorporation of any field or forage crop while green or soon after flowering, for the purpose of soil improvement. A cover crop is any crop grown to provide soil cover, regardless of whether it is later incorporated. Cover crops are grown primarily to prevent soil erosion by wind and water. Cover crops and green manures can be annual, biennial, or perennial herbaceous plants grown in a pure or mixed stand during all or part of the year. In addition to providing ground cover and, in the case of a legume, fixing nitrogen, they also help suppress weeds and reduce insect pests and diseases. When cover crops are planted to reduce nutrient leaching following a main crop, they are often termed “catch crops.”

Winter cover crop

A winter cover crop is planted in late summer or fall to provide soil cover during the win-

ter. Often a legume is chosen for the added benefit of nitrogen fixation. In northern states, the plant selected needs to possess enough cold tolerance to survive hard winters. Hairy vetch and rye are among the few selections that meet this need.

Many more winter cover crops are adapted to the southern U.S. These cool-season legumes include clovers, vetches, medics, and field peas. They are sometimes planted in a mix with winter cereal grains such as oats, rye, or wheat. Winter cover crops can be established by aerial seeding into maturing cash crops in the fall, as well as by drilling or broadcasting seed immediately following harvest.

Summer green manure crop

A summer green manure occupies the land for a portion of the summer growing season. These warm-season cover crops can be used to fill a niche in crop rotations, to improve the conditions of poor soils, or to prepare land for a perennial crop. Legumes such as cowpeas, soybeans, annual sweetclover, sesbania, guar, crotalaria, or velvet beans may be grown as sum-

mer green manure crops to add nitrogen along with organic matter. Non-legumes such as sorghum-sudangrass, millet, forage sorghum, or buckwheat are grown to provide biomass, smother weeds, and improve soil tilth.

Living mulch

A living mulch is a cover crop that is interplanted with an annual or perennial cash crop. Living mulches suppress weeds, reduce soil erosion, enhance soil fertility, and improve water infiltration. Examples of living mulches in annual cropping systems include overseeding hairy vetch into corn at the last cultivation, no-till planting of vegetables into subclover, sweetclover drilled into small grains, and annual ryegrass broadcast into vegetables. Living mulches in perennial cropping systems are simply the grasses or legumes planted in the alleyways between rows in orchards, vineyards, Christmas trees, berries, windbreaks, and field nursery trees to control erosion and provide traction.

Catch crop

A catch crop is a cover crop established after harvesting the main crop and is used primarily to reduce nutrient leaching from the soil profile. For example, planting cereal rye following corn harvest helps to scavenge residual nitrogen, thus reducing the possibility of groundwater contamination. In this instance, the rye catch crop also functions as a winter cover crop. Short-term cover crops that fill a niche within a crop rotation are also commonly known as catch crops.

Forage crop

Short-rotation forage crops function both as cover crops when they occupy land for pasturage or haying, and as green manures when they are eventually incorporated or killed for a no-till mulch. Examples include legume sods of alfalfa, sweet clover, trefoil, red clover, and white clover, as well as grass-legume sods like fescue-clover pastures. For maximum soil-improving ben-

efits, the forage should not be grazed or cut for hay during its last growth period, to allow time for biomass to accumulate prior to killing.

Benefits of Cover Crops and Green Manures

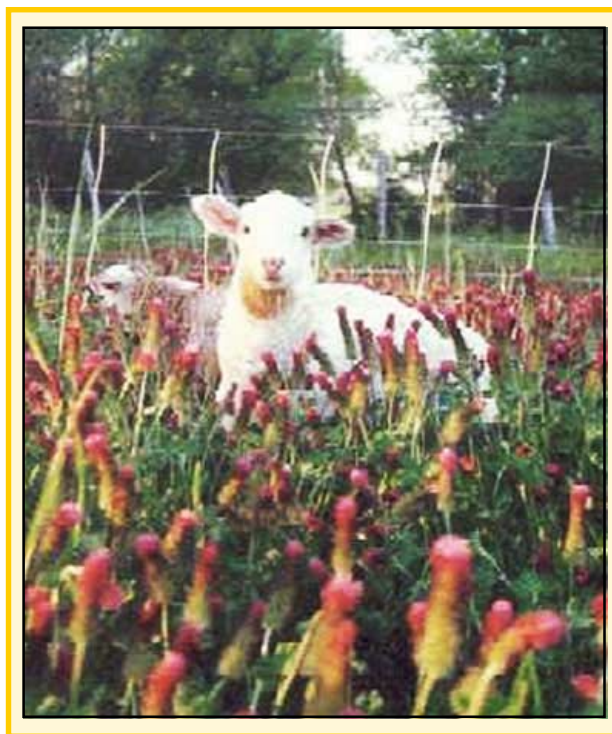
Organic matter and soil structure

A major benefit obtained from green manures is the addition of organic matter to the soil. During the breakdown of organic matter by microorganisms, compounds are formed that are resistant to decomposition—such as gums, waxes, and resins. These compounds—and the mycelia, mucus, and slime produced by the microorganisms—help bind together soil particles as granules, or aggregates. A well-aggregated soil tills easily, is well aerated, and has a high water infiltration rate.

Increased levels of organic matter also influence soil humus. Humus—the substance that results as the end product of the decay of plant and animal materials in the soil—provides a wide range of benefits to crop production.

Sod-forming grass or grass-legume mixtures are important in crop rotations because they help replenish organic

matter lost during annual cultivation. However, several years of sod production are sometimes required before measurable changes in humus levels occur. In comparison, annual green manures have a negligible effect on humus levels, because tillage and cultivation are conducted each year. They do replenish the supply of active, rapidly decomposing organic matter (1).



The contribution of organic matter to the soil from a green manure crop is comparable to the addition of 9 to 13 tons per acre of farm-yard manure or 1.8 to 2.2 tons dry matter per acre (2).

Table 1 shows dry matter production of several winter-annual legume cover crops grown in the southern U.S. Approximately 2.2 tons per acre per year of crop residue is considered adequate to maintain soil organic matter at constant levels in continuously cropped soils (3). This figure will vary according to climate, region, and cropping system.

Table 1. Average biomass yields and nitrogen yields of several legumes (4).

Cover Crop	Biomass	Nitrogen
	Tons/acre	Lbs./acre
Sweet clover	1.75	120
Berseem clover	1.1	70
Crimson clover	1.4	100
Hairy vetch	1.75	110

Nitrogen production

Nitrogen production from legumes is a key benefit of growing cover crops and green manures. Nitrogen accumulations by leguminous cover crops range from 40 to 200 lbs. of nitrogen per acre. The amount of nitrogen available from legumes depends on the species of legume grown, the total biomass produced, and the percentage of nitrogen in the plant tissue. Cultural and environmental conditions that limit legume growth—such as a delayed planting date, poor stand establishment, and drought—will reduce the amount of nitrogen produced. Conditions that encourage good nitrogen production include getting a good stand, optimum soil nutrient levels and soil pH, good nodulation, and adequate soil moisture.

The portion of green-manure nitrogen available to a following crop is usually about 40% to 60% of the total amount contained in the legume. For example, a hairy vetch crop that accumulated 180 lbs. N per acre prior to plowing down will contribute approximately 90 lbs. N per acre to the succeeding grain or vegetable crop. Dr. Greg

Hoyt, an agronomist at North Carolina State University, has estimated that 40% of plant tissue nitrogen becomes available the first year following a cover crop that is chemically killed and used as a no-till mulch. He estimates that 60% of the tissue N is released when the cover crop is incorporated as a green manure rather than left on the surface as a mulch. Lesser amounts are available for the second or third crop following a legume, but increased yields are apparent for two to three growing seasons (5).

To determine how much nitrogen is contained in a cover crop, an estimate is needed of the yield of above-ground herbage and its percentage of nitrogen. A procedure to make this determination is available in the *Northeast Cover Crop Handbook*, in *Farmer's Fertilizer Handbook*, and in *Managing Cover Crops Profitably*. A description of these publications complete with ordering information can be found in the [Resources](#) section below.

The procedure involves taking a field sample, drying it, weighing it, and sending a sample off for forage analysis, which includes an estimate of protein content. Once the protein content is known, simply divide it by 6.25 to obtain the percentage of nitrogen contained in the cover crop tissue. Finally, to obtain pounds of legume nitrogen per acre, multiply the nitrogen figure by the pounds-of-biomass figure.

Forage legumes are valuable in rotations because they generate income from grazing or haying and still contribute nitrogen from regrowth and root residues. A high percentage of biologically fixed nitrogen is in the top growth (Table 2).

Table 2. Percent nitrogen in legume tops and roots (6).

Crop	Tops	Roots
	% N	% N
Soybeans	93	7
Vetch	89	11
Cowpeas	84	16
Red clover	68	32
Alfalfa	58	42

Soil microbial activity

A rapid increase in soil microorganisms occurs after a young, relatively lush green manure crop is incorporated into the soil. The soil microbes multiply to attack the freshly incorporated

plant material. During microbial breakdown, nutrients held within the plant tissues are released and made available to the following crop.

Factors that influence the ability of microorganisms to break down organic matter include soil temperature, soil moisture, and carbon to nitrogen (C:N) ratio of the plant material. The C:N ratio of plant tissue reflects the kind and age of the plants from which it was derived (Table 3). As plants mature, fibrous (carbon) plant material increases and protein (nitrogen) content decreases (7). The optimum C:N ratio for rapid decomposition of organic matter is between 15:1 and 25:1 (6).

C:N ratios above 25:1 can result in nitrogen being “tied up” by soil microbes in the breakdown of carbon-rich crop residues, thus pulling nitrogen away from crop plants. Adding some nitrogen fertilizer to aid the decomposition process may be advisable with these high carbon residues. The lower the C:N ratio, the more N will be released into the soil for immediate crop use.

The C:N ratio is more a function of the plant’s N content than its carbon content. Most plant materials contain close to 40% carbon. To determine the C:N ratio of any plant material, divide 40% by its nitrogen content. For example let’s say hairy vetch contains 4.2% nitrogen: $40/4.2 =$ a C:N ratio of 9.5. A procedure for determining the nitrogen content of cover crop biomass was previously addressed in the section on nitrogen production. Estimating the nitrogen contribution of a cover crop is very helpful when adjusting N-fertilizer rates to account for legume nitrogen.

Table 3 provides a nice comparison of the typical C:N ratios that can be found in different

types of crop residues. The important point is that lush green manures are richer in nitrogen relative to carbon, especially in comparison to highly lignified crop residues like corn stalks. It will take a lot longer for soil microbes to break down corn stalks than fresh hairy vetch.

Table 3. Common C:N ratios of cover crops.

Organic Material	C:N Ratio	Reference
Young rye plants	14:1	4
Rye at flowering	20:1	4
Hairy vetch	10:1 to 15:1	8
Crimson clover	15:1	6
Corn stalks	60:1	4
Sawdust	250:1	9

Nutrient enhancement

In addition to nitrogen from legumes, cover crops help recycle other nutrients on the farm. Nitrogen (N), phosphorous (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), and other nutrients are accumulated by cover crops during a growing season. When the green manure is incorporated, or laid down as no-till mulch, these plant-essential nutrients become slowly available during decomposition. Dr. Greg Hoyt developed a method for estimating nutrient accrument by cover crops in order to reduce the soil test recommendation of fertilizer for the following crop (10). Table 4 shows the biomass and nutrients accumulated by several cover crops he worked with.

Table 4. Biomass yield and nutrient accrument by selected cover crops (10).

Crop	Biomass*	Nitrogen	Potassium	Phosphorus	Magnesium	Calcium
	lbs/ac	lbs/ac	lbs/ac	lbs/ac	lbs/ac	lbs/ac
Hairy Vetch	3,260	141	133	18	18	52
Crimson clover	4,243	115	143	16	11	62
Austrian W. P.	4,114	144	159	19	13	45
Rye	5,608	89	108	17	8	22

*Dry weight of aboveground plant material.

Certain broad-leaved plants are noted for their ability to accumulate minerals at high concentrations in their tissue. For example, buckwheat, lupine, and sweetclover are noted for their ability to extract P from soils. Likewise, alfalfa and other deep-rooting green manures scavenge

nutrients from the subsoil and translocate them upwards to the surface rooting zone, where they become available to the following crop.

The breakdown of green manures in soil influences mineral nutrient availability in another way. During decomposition of organic matter,

carbonic and other organic acids are formed as a byproduct of microbial activity. These organic acids react with insoluble mineral rocks and phosphate precipitates, releasing phosphates and exchangeable nutrients (6).

Rooting action

The extensive root systems of some cover crops are highly effective in loosening and aerating the soil. In Australian wheat experiments, the taproots of a blue lupine cover crop performed like a “biological plow” in penetrating compacted soils (11). When cover crops are planted after a subsoiling treatment, they help extend the soil-loosening effects of the deep tillage treatment. The rooting depths of several green manures grown under average conditions are listed in Table 5.

Table 5. Typical rooting depths of several green manure crops (2).

Depth (feet)	Green Manure Crop
5 to 7	Red Clover, Lupine, Radish, Turnips
3 to 5	Common Vetch, Mustard, Black Medic, Rape
1 to 3	White Clover, Hairy Vetch

Weed suppression

Weeds flourish on bare soil. Cover crops take up space and light, thereby shading the soil and reducing the opportunity for weeds to establish themselves. The soil-loosening effect of deep-rooting green manures also reduces weed populations that thrive in compacted soils.

The primary purpose of a non-legume green manure—such as rye, millet, or sudangrass—is to provide weed control, add organic matter, and improve soil tilth. They do not produce nitrogen. Thus, whenever possible, annual grain or vegetable crops should follow a legume green manure to derive the benefit of farm-produced nitrogen.

Providing weed suppression through the use of allelopathic cover crops and living mulches has become an important method of weed control in sustainable agriculture. Allelopathic plants are those that inhibit or slow the growth of other nearby plants by releasing natural toxins, or “allelochemicals.” Cover crop plants that exhibit allelopathy include the small grains like rye and summer annual forages related to sorghum and

sudangrass. The mulch that results from mowing or chemically killing allelopathic cover crops can provide significant weed control in no-till cropping systems. Living mulches suppress weeds during the growing season by competing with them for light, moisture, and nutrients.

Soil and water conservation

When cover crops are planted solely for soil conservation, they should provide a high percentage of ground coverage as quickly as possible. Most grassy and non-legume cover crops, like buckwheat and rye, fulfill this need well. Of the winter legumes, hairy vetch provides the least autumn ground cover because it puts on most of its above-ground growth in the spring. Consequently, it offers little ground cover during the erosion-prone fall and winter period. Sowing a mix of leguminous and grassy-type cover crops will increase the ground coverage, as well as provide some nitrogen to the following crop.

The soil conservation benefits provided by a cover crop extend beyond protection of bare soil during non-crop periods. The mulch that results from a chemically or mechanically killed cover crop in no-till plantings increases water infiltration and reduces water evaporation from the soil surface. Soil cover reduces soil crusting and subsequent surface water runoff during rainy periods.

Retention of soil moisture under cover crop mulches can be a significant advantage. Dr. Blevins and other researchers showed consistently higher soil-moisture levels for corn grown in a herbicide-killed, no-till bluegrass sod than for corn grown in conventionally plowed and disked plots (12). They concluded that the decreased evaporation and increased moisture storage under the no-till mulch allowed plots to survive a short-term drought without severe moisture stress.

Vegetation management to create a cover crop mulch

Herbicides are the most commonly used tools for cover crop suppression in conservation tillage systems. Non-chemical methods include propane flammers, mowing and mechanical tillage.

Mowing a rye cover crop when it heads out in late spring provides sufficient kill (13). The rye must be in the pollination phase, or later, to be successfully killed. When the anthers are fully extended and you can thump the stalk and pol-

len falls down, it is time to mow. If mowed earlier, it just grows back. Flail mowers generally produce more uniformly distributed mulch than do rotary cutters, which tend to windrow the mulch to one side of the mower. Sickle bar mowers create fairly uniform mulch, but the unchopped rye stalks can be more difficult to plant into. If late spring weather continues cool and wet, more rye regrowth will occur than if the weather remains warm and dryer. Typically, if rye is mowed at the pollination stage, regrowth is minimal and not a problem to crops grown in the mowed mulch.

In a Mississippi study, flail mowing, or rolling with rolling disk colters spaced at 4 inches, was usually as effective as herbicides in killing hairy vetch, crimson clover and subterranean clover (14). Timing is a key factor when using mowing or rolling to control cover crops. Mechanical control was most effective when the legumes were in the seed formation growth phase (mid to late April) or when stem lengths along the ground exceeded 10 inches (14). If mowing was followed with a pre-plant herbicide application of Atrazine, the legume kill was even more effective.

Researchers at Ohio State University developed a mechanical cover crop killing tool used to take out a cover crop without herbicides. They call it an undercutter because it uses wide V-blades which run just under the soil surface to cut off the cover crop from its roots. The blades are pitched to 15 degrees allowing the blades to penetrate the soil and provide a slight lifting action. Mounted on the same toolbar behind the cutter blades is a rolling basket to flatten and distribute the undercut cover crop. The undercutter was tried on several cover crops and effectively killed crimson clover, hairy vetch, rye, and barley. These undercutters could be made from locally available stock by innovative tinkerers.

Steve Groff of Cedar Meadow Farm in Lancaster County, Pennsylvania, uses a 10-foot Buffalo rolling stalk chopper from Fleischer Manufacturing (15) to transform a green cover crop into a no-till mulch (see Figure 1). Under the hitch-mounted frame, the stalk chopper has two sets of rollers running in tandem. These roll-

ers can be adjusted for light or aggressive action and set for continuous coverage. Steve says the machine can be run up to 8 miles an hour and does a good job of killing the cover crop and pushing it right down on the soil. It can also be used to flatten down other crop residues after harvest. Groff improved his chopper by adding independent linkages and springs to each roller. This modification makes each unit more flexible to allow continuous use over uneven terrain. Following his chopper, Groff transplants vegetable seedlings into the killed mulch. He direct-seeds sweet corn and snap beans into the mulch. For more information on this system, order Steve's videos listed under the [Videos](#) section of this publication, or visit his Web page, which is listed under the [Web Resources](#) section. At the Web site you can see photos of these machines in action, and test-plot results comparing flail mowing, rolling, and herbicide-killed cover crops.



Figure 1. Steve Groff's modified rolling stalk chopper. (From www.cedarmeadowfarm.com)

Two USDA-ARS researchers, Drs. Aref Abdule-Bake and John Teasdale of the Beltsville Maryland Research Center, have developed a cover-crop roller (Figure 2) that acts, in principle, similarly to Steve Groff's rolling chopper. In their extensive research trials using hairy vetch, they no-till planted tomatoes into a mechanically killed hairy vetch cover crop (Figure 3). Details of their research—and other useful information on flail-mowing of cover crops and direct no-till seeding of sweet corn and snap beans into mechanically killed cover crops—can be seen in the USDA Farmer's Bulletin No. 2279, listed under the [Web](#)

Resources section below. As of this writing the bulletin is available only on-line because the first printing of it was all distributed to farmers and their advisors in a very short time.

where farmers want to plant early in the spring and avoid overwintered cover crops altogether.

Limitations of cover crops

The recognized benefits of green manuring and cover cropping—soil cover, improved soil structure, nitrogen from legumes—need to be evaluated in terms of cash returns to the farm as well as the long-term value of sustained soil health. For the immediate growing season, seed and establishment costs need to be weighed against reduced nitrogen fertilizer requirements and the effect on cash crop yields.

Water consumption by green manure crops is a concern and is pronounced in areas with less than 30 inches of precipitation per year. Still, even in the fallow regions of the Great Plains and Pacific North-



Figure 2. A homemade roller to kill cover crops (From USDA Farmer's Bulletin No. 2279).



Figure 3. Transplanting tomatoes into mechanically killed hairy vetch. (From USDA Farmer's Bulletin No. 2279).

Planting cover crops known to readily winter-kill is another non-chemical means of vegetation management. Spring oats, buckwheat, and sorghum fill this need. They are fall-planted early enough to accumulate some top growth before freezing temperatures kill them. In some locations, oats will not be completely killed and some plants will regrow in the spring. Winter-killed cover crops provide a dead mulch through the winter months instead of green cover. They are used primarily in regions where precipitation is limited, such as West Texas, and in situations

west, several native and adapted legumes (such as black medic) seem to have potential for replacing cultivation or herbicides in summer fallow. There is always additional management required when cover crops of any sort are added to a rotation. Turning green manures under or suppressing cover crops requires additional time and expense, compared to having no cover crop at all.

Insect communities associated with cover crops work to the farmer's advantage in some crops and create a disadvantage in others. For

example, certain living mulches enhance the biological control of insect pests of summer vegetable crops and pecan orchards by providing favorable habitats for beneficial insects. On the negative side, winter legumes that harbor catfacing insects such as the tarnished plant bug, stink bug, and plum curculio can pose problems for apple or peach orchardists in the eastern U.S. Nematodes encouraged by certain legumes on sandy soils are another concern of farmers, as are cutworms in rotations following grain or grass crops.

Cover crops in rotation

Cover crops can fit well into many different cropping systems during periods of the year when no cash crop is being grown. Even the simplest corn/soybean rotation can accommodate a rye cover crop following corn, which will scavenge residual nitrogen and provide ground cover in the fall and winter. When spring-killed as a no-till mulch, the rye provides a water-conserving mulch and suppresses early-season weeds for the following soybean crop. Hairy vetch can be planted behind soybeans to provide nitrogen for corn the following spring. Hairy vetch is *not* a good cover crop to use when small grains are included in the rotation—if the vetch ever goes to seed it can become a terrible weed in the small grain crop. In these cases, crimson clover, sweet clover, or red clover should be used, depending on location.

Many vegetable rotations can accommodate cover crops as well. Buckwheat can follow lettuce and still be tilled down in time for fall broccoli. Hairy vetch works well with tomatoes and other warm-season vegetables. The vetch can be killed by flail mowing and tomato sets planted into the mulch. For more details on the vetch-tomato system see Steve Groff's Web page, listed under [Web Resources](#) below. *Managing Cover Crops Profitably* has a nice section on crop rotation with cover crops, starting on page 34. For ordering information on this handbook, see the [Publications in Print](#) section below.

Pest management benefits of cover crops

In addition to the soil improving benefits, cover crops can also enhance many pest management programs. Ecologists tell us that stable natural systems are typically diverse, containing many different types of plants, arthropods, mammals, birds, and microorganisms. Growing cover crops adds diversity to a cropping system. In

stable systems, serious pest outbreaks are rare, because natural controls exist to automatically bring populations back into balance.

Farmers and researchers in several locations have observed and documented increased beneficial insect numbers associated with cover crops. The cover crops provide pollen, nectar, and a physical location for beneficial insects to live while they search for pest insects. Conservation tillage proves a better option than tilling because it leaves more crop residue on the surface to harbor the beneficial insects. Strip tilling or no-tillage disturbs a minimum of the existing cover crop that harbors beneficial insects. Cover crops left on the surface may be living or in the process of dying. At either of these stages they protect beneficials. Once the main crop is growing, the beneficials move onto it. By having the cover crop in place early in the growing season, the population of beneficials is much higher sooner in the growing season than would be the case if only the main crop were serving as habitat for the beneficials.

Innovative farmers are paving the way by interplanting cover crops with the main crop and realizing pest management benefits as a result. Georgia cotton farmers Wayne Parramore and sons reduced their insecticide and fertilizer use by growing a lupine cover crop ahead of their spring-planted cotton (16). They started experimenting with lupines on 100 acres in 1993 and by 1995 were growing 1,100 acres of lupines. Ground preparation for cotton planting is begun about 10 days prior to planting by tilling 14-inch wide strips into the lupines. Herbicides are applied to the strips at that time and row middles remain untouched. The remaining lupines provide beneficial insect habitat and also serve as a smother crop to curtail weeds and grasses. The lupines in the row middles can be tilled in later in the season to release more legume nitrogen.

Dr. Sharad Phatak of the University of Georgia has been working with cotton growers in Georgia testing a strip cropping method using winter annual cover crops (17). Planting cotton into strip-killed crimson clover improves soil health, cuts tillage costs, and allows him to grow cotton without any insecticides and only 30 pounds of nitrogen fertilizer. Working with Phatak, farmer Benny Johnson reportedly saved at least \$120/acre on his 16-acre test plot with the clover system. There were no insect problems in the test plot, while beet armyworms and

whiteflies infested nearby cotton and required 8 to 12 sprays to control. Cotton intercropped with crimson clover yielded more than 3 bales per acre compared with 1.2 bales per acre in the rest of the field (17). Boll counts were 30 per plant with crimson clover and 11 without it. Phatak identified up to 15 different kinds of beneficial insects in these strip-planted plots.

Phatak finds that planting crimson clover seed at 15 pounds per acre in the fall produces around 60 pounds of nitrogen per acre by spring. By late spring, beneficial insects are active in the clover. At that time, 6- to 12-inch planting strips of clover are killed with Roundup herbicide. Fifteen to 20 days later the strips are lightly tilled and cotton is planted. The clover in the row-middles is left growing to maintain beneficial insect habitat. When the clover is past the bloom stage and less desirable as a preferred habitat, beneficials move onto the cotton. Even early-season thrips, which can be a problem following cover crops, are limited or prevented by beneficial insects in this system. Movement of the beneficials coincides with a period when cotton is most vulnerable to insect pests. Following cotton defoliation in the early fall, the beneficials hibernate in adjacent non-crop areas.

Phatak points out that switching to a whole-farm focus while reducing off-farm inputs is not simple. It requires planning, management, and several years to implement on a large scale. It is likewise important to increase and maintain organic matter, which stimulates beneficial soil microorganisms. Eventually a “living soil” will help keep harmful nematodes and soil-borne fungi under control (17).

The two *Creative Cover Cropping* videos from California, listed under the [Videos](#) section below, show footage of cover crop systems used to provide beneficial insect habitat and how to manage them. *Managing Cover Crops Profitably* has a section on using cover crops for pest management starting on page 25. See the [Publications in Print](#) section for ordering information. Additional concepts and practices associated with cover crops as a tool to build soil health and increase agroecosystem diversity in relation to pest management are contained in the following ATTRA publications: [Farmscaping to Enhance Biological Control](#) and [Alternative Nematode Control](#).

Table 6. Optimum nitrogen rates and profitability of several cover crops (19).

Cover Crop	Corn Yield bu./acre	Optimum N rate lbs N/acre
No cover crop	142	100
Winter wheat	142	126
Hairy vetch	148	79
Austrian winter peas	153	107
Crimson clover	148	94

Economics of cover crops

The most obvious direct economic benefit derived from legume cover crops is nitrogen fertilizer savings. In most cases these savings can offset cover crop establishment costs. Indirect benefits include herbicide reduction in the case of an allelopathic rye cover crop, reduction in insect and nematode control costs in some cases, protection of ground water by scavenging residual nitrate, and water conservation derived from a no-till mulch. Longer-term benefits are derived from the buildup of organic matter resulting in increased soil health. Healthy soils cycle nutrients better, don't erode, quickly absorb water after each rain, and produce healthy crops and bountiful yields.

With annual cover crops, the highest cost is seed. Hairy vetch and crimson clover typically range from 50¢ to \$1.50 per pound. With a 20-pound per acre seeding rate, seed costs range from \$10 to \$30 per acre. With a 25-pound seeding rate at 85¢/lb and a \$6.50 no-till drilling cost, it would cost \$28 to plant an acre of this cover crop.

In a Maryland study, hairy vetch was compared to a winter wheat cover crop or no cover crop at two different locations (coastal plain and piedmont) (18). Corn was grown following the cover crops. Nitrogen fertilizer was used with the cover crops at varying rates. The most profitable cover crop and nitrogen fertilizer combination used more than 100 lbs of additional nitrogen per acre plus the cover crop. At \$2.50 per bushel corn price, highest returns at the coastal plain location were realized with 120 lbs of additional nitrogen per acre. Profits were as follows: \$53.75 per acre from no cover crop, \$95.62 from hairy vetch, and \$32.47 from winter wheat cover crop. All corn crops needed additional nitrogen. Lower N rates were less profitable. At the pied-

mont location, also with \$2.50 corn, winter fallow was most profitable at \$68.03 with 40 lbs per acre additional N, hairy vetch was profitable at \$56.57 with 40 lbs per acre, and winter wheat was profitable at \$30.12 with 100 lbs of additional nitrogen.

In another Maryland study (19), optimum nitrogen rates for corn were determined when corn followed four cover crops, compared to a winter fallow (no cover crop) treatment. Corn was grown following each cover crop treatment at various nitrogen rates over a three-year period. The results are shown in Table 6. The optimum nitrogen rate is the rate above which no additional yield increases are realized. The researchers concluded that cover crops can benefit a succeeding corn crop not only by supplying nitrogen but also by increasing maximum yield of the system (19).

Many studies have shown that legume cover crops can replace a portion of the fertilizer nitrogen requirements for a following crop. Some of these replacement values can be seen in Table 7. The economic value of these nitrogen replacements can be calculated by using a local nitrogen price. These costs can then be compared to cover crop seed and planting costs. These simple nitrogen cost comparisons do not take into account the benefits of improved soil tilth and increased water infiltration resulting from cover crops.

In a Kentucky study (25), economic returns above direct expenses for no-till corn were \$64 greater with hairy vetch plus 90 lbs of nitrogen fertilizer per acre than with no cover crop plus the same nitrogen rate. This advantage was mostly due to the yield increase under the legume cover crop of 36 bushels per acre. Some researchers have stated that advantages of legume cover crops can only be realized if they increase yields of a following crop over yields obtained from no cover crop. In other words, the nitrogen replacement value is insufficient to offset the establishment costs of the cover crop without an increase in crop yield. When these

yield increases beyond the nitrogen benefit occur, they are due to improved soil water use efficiency and other soil health benefits from the cover crop.

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Table 7. Nitrogen fertilizer replacement value of legume cover crops.

Cover Crop	N replacement value (lbs/acre)	Reference
Hairy vetch	80-89	Ebelhar, et al., 1984 (20)
Hairy vetch	170	Utomo, et al., 1990 (21)
Winter legumes	64-69	Hargrove, et al., 1986 (22)
Hairy vetch	110	McVay, et al., 1989 (23)
Crimson clover	88	McVay, et al., 1989 (23)
Winter legumes	75	Tyler, et al., 1987 (24)

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2281 16th Avenue
P.O. Box 848
Columbus, NE 68602-0848
800-228-1405
402-564-3244
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Resources

In most states the Extension service and Agricultural Experiment Stations offer free or low-cost publications on cover crops to state residents. Examples include: *Effects of Winter Cover Crops on Yield of Cotton and Soil Properties* (Arkansas Agricultural Experiment Station Bulletin 924), *Planting Guide for Forage Crops* (North Carolina Extension Service publication AG-226), and *Cover Crops* (Mississippi Cooperative Extension Service Publication 1552). Contact these local sources to obtain information adapted to your immediate area.

Publications in Print

Managing Cover Crops Profitably, 2nd Edition. 1998. The Sustainable Agriculture Network. This publication is one of the most comprehensive hands-on resources available. The book is organized by the different geographic regions of the United States. Covered in the book are selection of the best species for your location, planning profitable crop rotations, crop yield benefits following cover crops, and fertilizer reduction realized from cover crops. Chapters on 18 different cover crop species and charts rating many factors for each species, including drought tolerance, nitrogen yield, and seeding rates. The top six high-performing cover crops for each region are discussed. This publication may be ordered for \$19.00 plus \$3.95 shipping from:

Sustainable Agriculture Publications
210 Hills Building
University of Vermont
Burlington, VT 05405-0082
802-656-0471

Excerpts from the 2nd Edition can also be found on the SAN Web site: <http://www.sare.org/mccp2/>

Northeast Cover Crop Handbook. 1994. 118 pages. Marianne Sarrantonio. Among the topics covered in this comprehensive and practical manual on using cover crops are how to choose the right cover crop for your operation, building a rotation around cover crops, choosing the best species for the whole farm, estimating the nitrogen contribution from a green manure, looking at soil improvements from cover crops, and lowering the cost of cover cropping. The book is well written and easy to read, with lots of drawings and simple charts. The appendix contains detailed management practices for 20 cover crop species, cover crop seed sources, and other information sources. To order this publication send \$12.00 plus \$5.50 shipping and handling to:

Rodale Institute Bookstore
611 Siegfriedale Road
Kutztown, PA 19530
800-832-6285
610-683-6009
<http://www.rodaleinstitute.org>

Green Manuring: Principles and Practice of Natural Soil Improvement. 1989. 51 pages. This publication contains an excellent review of the benefits and uses of green manure cover crops. This 51-page spiral-bound book is largely based on green manuring trials in Switzerland and is supplemented with cover crop data compiled by Woods End Agricultural Institute of Maine and The New Alchemy Institute of Massachusetts. Although much of the discussion is based on the use of green manures in Switzerland, the cultural practices are just as applicable to farming systems in the United States. Tables include seeding rates and cost of seed per acre, biomass yields and nutrient contents, and characteristics of selected living mulches. The 1989 edition, unlike the earlier editions, also contains an extensive list of seed sources in the U.S. It is available for \$20, which includes shipping and handling, from:

Woods End Agricultural Institute
PO Box 297
Mt. Vernon, ME 04352
207-293-2457
<http://www.woodsend.org>

Covercrops for California Agriculture by P.R. Miller, W.L. Graves, W.A. Williams, and B.A. Madison is California Extension Leaflet No. 21471, published in December of 1989. This 24-page leaflet contains information on using cover crops for soil improvement, selecting cover crops, growing and working in cover crops, biological interactions, and an appendix on cover crop management systems. It can be obtained for \$3.50 plus \$2.00 shipping and handling from:

University of California, ANR
Communication Services
6701 San Pablo Avenue
Oakland, CA 94608-1239
510-642-2431
<http://anrcatalog.ucdavis.edu>

Cover Cropping in Vineyards by Chuck Ingles, University of California Publication number 3338. Published in 1998 with 168 pages. The publication offers cover cropping methods for enhancing vineyard performance. Provides detailed information on how cover crops promote ecological stability. Useful to vineyard owners, managers, consultants, and pest control advisors. Avail-

able for \$20 plus \$5 shipping and handling from:

University of California, ANR
Communication Services
6701 San Pablo Avenue
Oakland, CA 94608-1239
510-642-2431
<http://anrcatalog.ucdavis.edu>

Cover Crops: Resources for Education and Extension. 1998. 3-ring binder. To order, send \$20.00 postpaid, U.S. check or money order (payable to "UC Regents"; write title of publication on the check) to:

UC SAREP
University of California
One Shields Ave.
Davis, CA 95616-8716
530-752-7556
530-754-8550 FAX
sarep@ucdavis.edu
<http://www.sarep.ucdavis.edu>

Videos

No-till Vegetables by Steve Groff. 1997. Steve is a 15-year no-till farmer in Lancaster County, Pennsylvania, who uses cover crops extensively in his crop fields. Steve farms 175 acres of vegetables, alfalfa, and grain crops on his Cedar Meadow Farm. This video leads you through selection of the proper cover crop mix to plant into and how to control cover crops with little or no herbicide. You will see Groff's mechanical cover-crop-kill method, which creates ideal no-till mulch without herbicides. Vegetables are planted right into this mulch using a no-till transplanter. He grows high-quality tomatoes, pumpkins, broccoli, snap beans, and sweet corn. After several years of no-till production his soils are very mellow and easy to plant into. You'll also hear comments from leading researchers in the no-till vegetable area. Order this video for \$21.95 plus \$3.00 shipping from:

Cedar Meadow Farm
679 Hilldale Road
Holtwood, PA 17532
717-284-5152
<http://www.cedarmeadowfarm.com>

Creative Cover Cropping in Annual Farming Systems. 1993. Produced by the University of California, this video depicts opportunities and con-

straints of cover crop use. The film shows many types of cover crops used in various annual cropping systems for soil fertility and pest management. 24 minutes. Item number V93-V.

Creative Cover Cropping in Perennial Farming Systems. 1993. Produced by the University of California. Teaches how cover crops can be used to protect and improve soil fertility, enhance pest control, and provide other benefits. Creative management options are shown with a wide variety of cover crops used in orchards and vineyards. 27 minutes. Item number V93-W.

To order either or both of these videos send \$15.00 plus \$4.00 shipping and handling each to:

University of California
ANR Communication Services
6701 San Pablo Avenue
Oakland, CA 94608-1239
510-642-2431
<http://anrcatalog.ucdavis.edu>

Web Resources

USDA's Sustainable Agriculture Network (SAN)
<http://www.sare.org/>

This site offers the first edition of Managing Cover Crops Profitably on-line and a database of other sustainable agriculture research and education projects. Many of these projects have a cover crop component and some are focused on cover crops.

Managing Cover Crops Profitably
<http://www.sare.org/handbook/mccp2/index.htm>

The on-line version of the first edition mentioned in the paper publication listed above. It summarizes more than 30 cover crops by region. Published in 1991.

UC SAREP Cover Crop Resource Page
<http://www.sarep.ucdavis.edu/ccrop>

This is the database of all databases when it comes to cover crops. The UC-SAREP Cover Crop Database includes more than 5,000 items gleaned from more than 600 separate sources, including journal articles, conference proceedings, standard textbooks, unpublished data, and personal communications from researchers and farmers. The information in the database concerns the management and effects of more than 32 species of plants usable as cover crops. More

than 400 different cover crop images are also available for online viewing. One limitation — the database is regionally geared to the Mediterranean climate of California. Ideally, each region of the U.S. should enjoy such site-specific information.

The Farming Connection

<http://sunsite.unc.edu/farming-connection/covercro/home.htm>

This site has farmer features and links to other cover crop sites. It also contains seed sources, general information, Steve Groff's No-till Vegetables video listing, and the first edition of Managing Cover Crops Profitably.

Ohio State On-line Ag Facts

<http://ohioline.osu.edu/agf-fact/0142.html>

This site has an on-line version of Cover Crop Fundamentals by Alan Sundermeier, publication number AGF-142-99. This publication covers the benefits of cover crops, planting times, types of cover crops, managing cover crop growth, and return on investment.

Michigan Cover Crops, Michigan State University and Kellogg Biological Station

<http://www.kbs.msu.edu/Extension/Covercrops/home.htm>

The Basics of Green Manuring

P. Warman. EAP Publication 51, Ecological Agriculture Projects

<http://eap.mcgill.ca/Publications/EAP51.htm>

Cover Crops & Green Manure Crops for Vegetable Farms

Ohio Vegetable Production Guide 2000

http://www.ag.ohio-state.edu/~ohioline/b672/b672_1.html

Summer Cover Crops for Tomato Production in South Florida

<http://www.imok.ufl.edu/veghort/pubs/workshop/Bryan99.htm>

Cover Cropping in Potato Production

EAP Publication 71, Ecological Agriculture Projects

<http://eap.mcgill.ca/Publications/EAP71.htm>

Cedar Meadow Farm's New Generation Cropping Systems

<http://www.cedarmeadowfarm.com>

Steve Groff's New Generation Cropping Systems Web page. Shows action shots of no-till planting into mechanically killed cover crops and ordering information for Steve Groff's No-till Vegetables video mentioned above.

USDA Web Site

<http://www.ars.usda.gov/is/np/tomatoes.html>

1997. By Aref Abdul-Baki and John R. Teasdale. USDA Farmers' Bulletin No. 2279. 23 p. This Web site provides the USDA Farmer's Bulletin that features the no-till vegetable cropping system developed by scientists at the USDA-ARS Vegetable Laboratory in Beltsville, Maryland. This system relies on hairy vetch established in the fall, followed by a mow-down treatment the following spring to prepare a no-till bed to transplant tomatoes and other vegetable crops.

Sustainable Agriculture Network Web site

<http://www.sare.org/htdocs/pubs/mccp/>

Managing Cover Crops Profitably, 1st Edition (1991).

Sustainable Agriculture Network

<http://www.sare.org/htdocs/pubs/resources/index.html>

Order the on-line version of: Managing Cover Crops Profitably, 2nd Edition (1998).

Multiple Impacts Cover Crops.

John Luna, Oregon State University

http://ifs.orst.edu/pubs/multiple_impacts_cover_cro.html

A comprehensive piece on cover crops and their benefits.

Cover Cropping in Row and Field Crop Systems

<http://www.sarep.ucdavis.edu/ccrop//slideshows/rfshow01.htm>

An online educational slide series that provides visual images and text describing the benefits and uses of cover cropping in annual crops like vegetables. 52 slides.

Cover Crop Biology: A Mini-Review
Robert L. Bugg
Sustainable Agriculture Research & Education
Program, University of California
[http://www.sarep.ucdavis.edu/ccrop/ccres/
/35.htm](http://www.sarep.ucdavis.edu/ccrop/ccres/35.htm)

Cover Crops for Sustainable Agriculture – IDRC
http://www.idrc.ca/cover_crop/index_e.html

Cover Crops and Living Mulches. Sustainable
Practices for Vegetable Production in the South
Dr. Mary Peet, NCSU
[http://www.cals.ncsu.edu/sustainable/peet/
cover/c02cover.html](http://www.cals.ncsu.edu/sustainable/peet/cover/c02cover.html)

Planting Dates, Rates, and Methods of Field and
Forage Crops. University of Florida, Institute of
Food and Agricultural Sciences
<http://edis.ifas.ufl.edu/AA127>

Uses of Cover Crops by Janet Wallace, NSOGA
<http://www.gks.com/nccrp/usesofcc.php3>

Organic Matter/Cover Crops: Green Manure
Crops for Vegetable Farms. Obtaining Accept-
able Stands of Clover and Green Manure Crops.
2000 Ohio Vegetable Production Guide, Bulletin
672-00.
[http://ohioline.osu.edu/b672/
organic_matter_cover_crops.html](http://ohioline.osu.edu/b672/organic_matter_cover_crops.html)

Additional Information from ATTRA

ATTRA can provide more information on specific cover crops via reprints, summaries of research, and other resources. This includes materials on living mulches, summer green manures, winter cover crops, and allelopathic cover crops, as well as on specific cover crops like hairy vetch and subterranean clover, and on the more obscure cover crops such as crotalaria, velvet bean, sesbania, and phacelia.

By Preston Sullivan
NCAT Agriculture Specialist

Edited by Paul Williams
Formatted by Gail Hardy

July 2003

The electronic version of **Overview of Cover Crops and Green Manures** is located at:
HTML
<http://www.attra.ncat.org/attra-pub/covercrop.html>
PDF
[http://www.attra.ncat.org/attra-pub/PDF/
covercrop.pdf](http://www.attra.ncat.org/attra-pub/PDF/covercrop.pdf)

Eat Mountain Mandarins for your Health!

Mandarins are an easy, healthy snack.

- Mandarins are very high in vitamin A, vitamin C, and thiamin.
- One cup of mandarin sections provides 100% of the daily adult requirement for Vitamin C and 18% of Vitamin A.
- Mandarins are also a good source of calcium and potassium.
- Mandarins are low in saturated fat and sodium and high in fiber.
- USDA research has shown that mandarin juice contains significant amounts of synephrine. Synephrine is a natural antihistamine, which may alleviate the symptoms of colds and allergies.
- Mandarins also contain phytochemicals such as carotenoids and flavonoids which may have antioxidant and anticancer properties.
- Research conducted at Japan's National Institute of Fruit Tree Science suggests that eating mandarins may reduce the risk of developing serious health conditions such as liver disease, insulin resistance and atherosclerosis (hardening of the arteries).

Mandarin Handling and Storage

- Mandarins are perishable and have a shorter shelf life than sweet oranges.
- Handle them carefully, because they do have a relatively thin skin which is easily punctured.
- Store in a cool place, at 60° to 70°F for up to one week.
- Refrigerator temperatures may alter mandarin flavor, so it is best to store them outside of the refrigerator unless you need to keep them for more than a few weeks.

Adapted from *Reasons for the Seasons*,
<http://ucce.ucdavis.edu/files/filelibrary/1808/8180.pdf>



Placer County Mountain Mandarins



Cindy Fake
Horticulture & Small Farms Advisor



University of California
Cooperative Extension
Placer & Nevada Counties

11477 E Ave.
Auburn, CA 95603
(530) 889-7385



Mandarin Facts



- Properly speaking, mandarins are not mandarin oranges, but simply mandarins.
- High quality “Mountain Mandarins” are grown in the foothills from 400 to 1200 feet elevation.
- Mandarins are among the most cold tolerant citrus, only kumquats are more cold tolerant.
- The botanical name for Mandarin is *Citrus reticulata*, which means it is in the genus *Citrus*. The word *reticulata* means netted and refers to the inner part of the peel and its netlike characteristics.
- All loose skinned, cold-hardy citrus are mandarins, including what are commonly called tangerines.
- Tangerine is a marketing term, created to sell the bright colored varieties of common mandarins in the United States. Mandarins were first imported from China into the Mediterranean region through the port of Tangiers, Morocco, hence the name tangerine.

Satsuma Mandarins

- Mandarins originated in China and were taken to India by traders. Later they spread to Japan, where Satsuma mandarins, known as Unshû (Unshiu) mikan, developed about three hundred years ago.
- Most commercial citrus production in the foothills is ‘Owari’ Satsuma mandarins. They are orange-colored, 2 to 3-inch fruit, with a slightly flattened shape. Owaris are sweet, seedless, and easy to peel.



- ‘Okitsu Wase’ is a Satsuma similar to ‘Owari’, but, as the word ‘wase’ indicates, it ripens one to two weeks earlier than Owari Satsumas.
- ‘Dobashi Bene’ is an early maturing Satsuma with deep orange-red color. It originated as a natural mutation of ‘Owari’ in Shizuoka Prefecture, Japan around 1940.

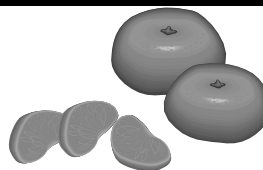
Clementine Mandarins

- Clementine mandarins (“Algerians”) came to California from the Mediterranean and Florida. The fruit is a deeper orange than Satsumas, with a more rounded shape. They are often called tangerines because of their reddish orange color. The skin is loose enough to peel easily, and the fruit is sweet, juicy, and very aromatic. They are usually seedless unless there is a pollenizer nearby.
- ‘Clemenules’, more properly called *Clementino de Nules* is a Spanish Clementine clone, which originated as a natural mutation called a bud sport, in Nules, Castellón Province. It is the most widely planted mandarin in Spain.

More Mandarin Information

- Citrus*. 1996. Lance Walheim. Ironwood Press.
- Citrus: How to Select, Grow and Enjoy*. 1980. Richard Ray & Lance Walheim. HP Books.
- Citrus in the Foothills*. 2004. Cindy Fake. UCCE Placer Pub. 31-112.
- Citrus Varieties of the World*. 1990. James Saunt. Sinclair International.
- Horticultural Varieties of Citrus*. 1967. Robert W. Hodgson. UC Division of Agricultural Sciences.
- A Mandarin by Any Other Name*. 2004. Cindy Fake. UCCE Placer Pub. 31-111.
- Satsuma Mandarins for the Foothill Garden*. 2003. D. Newman & C. Fake. UCCE Placer 31-109.

A MANDARIN BY ANY OTHER NAME



Publication
Number
31-111
(published Dec. 2004)

Author: Cindy Fake, Horticulture and Small Farms Advisor, Placer and Nevada Counties

A mandarin by any other name would taste as sweet, but what is it? In Japanese, mandarin is *mikan*; in India, it is the *suntara*. In French and German, it is *mandarine*; in Italian, *mandarino*, Spanish, Portuguese, Romanian, and Bulgarian all use *mandarina*; but to many Americans, mandarin is an unfamiliar term.

There is a lot of confusion about mandarins and tangerines. Some people say that if the skin is reddish-orange and it has seeds, it is a tangerine, and that only Satsumas are mandarins. Others think all of them are tangerines. Part of the confusion is because mandarins make up the largest and most varied group of citrus.

THE MANDARIN

According to most of the world's citrus experts, all of the loose skinned, cold-hardy citrus are mandarins, botanically known as *Citrus reticulata*. Properly speaking, they are not mandarin oranges, but simply mandarins. However, since many Americans' only acquaintance with mandarins is from a can labeled "mandarin oranges", it may be helpful to call them mandarin oranges, even if it is not



technically correct. Interestingly, DNA technology has revealed that the common or sweet orange is probably a hybrid of a pummelo, a large, thick-skinned citrus, and a mandarin. So, even your orange is part mandarin!

Where did tangerine come from? Mandarins were first imported from China into the Mediterranean region through the port of Tangiers, hence the name tangerine. However, to quote one citrus expert, Lance Walheim, "The name tangerine has no botanical standing; rather it appears to have developed as a marketing term for bright colored (reddish-orange) varieties of common mandarin, such as Dancy".

Use of the term tangerine is not consistent, as some pale yellow-orange fruit are also called tangerines. Outside the US, the term is rarely used. To put it succinctly, a mandarin is a mandarin and so is a tangerine.

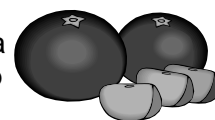
MANDARIN TYPES

Most horticulturalists divide mandarins into four groups:

1. **Satsuma mandarins** primarily developed in Japan. These are the most cold hardy mandarins.

2. **Mediterranean mandarins**, called "Willowleaf" mandarin because of its small narrow leaves
3. **King mandarins**, a small group of mandarins of Indo-China, important primarily as parents of commercial varieties such as Kinnow and Encore

4. **Common mandarins**, a diverse group that includes numerous hybrids and many of what some would call tangerines; the Clementines, Dancy, Kinnow, and Fairchild



Satsuma and common mandarins are the two commercially important groups. While some varieties fit easily into these four categories, one of the properties of mandarins (and other citrus) is that they mutate spontaneously. Many of the wide range of Satsuma and Clementine varieties are the result of such mutations.

HISTORY OF THE MANDARIN

Mandarins probably originated in China and were taken to India by traders. Later they spread to Japan, where Satsuma



COOPERATIVE EXTENSION, UNIVERSITY OF CALIFORNIA

Placer County

WEB SITE: ceplacervevada.ucdavis.edu

Nevada County



11477 E Avenue
Auburn, California 95603
(530) 889-7385
FAX (530) 889-7397
E-Mail: ceplacer@ucdavis.edu

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United States Department of Agriculture, University of California, Placer and Nevada Counties cooperating.

255 So Auburn
Grass Valley, California 95945
(530) 273-4563
FAX (530) 273-4769
E-Mail: cenevada@ucdavis.edu

mandarins developed about three hundred years ago.

Although citrus has been grown in Europe and the Mediterranean since Greek and Roman times, mandarins arrived in Europe much later than other citrus. What traveled to Europe was willowleaf and common mandarin. Our California mandarins trace back to the European and Japanese introductions.

SATSUMA MANDARINS

Our Satsuma varieties came to us from Japan. Most of the commercial production in the foothills is 'Owari' Satsuma mandarins. They are orange-colored 2 to 3 inch fruit, with a slightly flattened shape. Other Satsuma varieties include Okitsu Wase, Kuno Wase, and Dobashi Beni. Satsuma varieties are popular because they are sweet, seedless, and easy to peel and separate.

Satsuma mandarin trees are very cold hardy, but the fruit is considerably less so. Trees have been known to survive down to 16 degrees, but fruit will be damaged if temperatures fall below 28°F for just a few hours.



CLEMENTINE MANDARINS

Our Clementines, also known as "Algerian tangerines" came to California from the Mediterranean and via Florida. Clementines are

frequently called tangerines because of their reddish orange color.

The original 'Clementine' mandarin was selected in Oran, Algeria in the early 20th century by a French missionary, Father Clement Rodier. Although some sources have described it as an accidental hybrid of sour (Seville) orange and Mediterranean mandarin, it is now thought to be identical to the Canton mandarin of China. There have been so many selections of the original Clementine that Clementine is now used as a term for a group of varieties, which include Clemenules, Fina, Marisol, and Oroval.

Clementine fruit are usually seedless, unless there is a pollenizer nearby. They are a deeper orange than Satsumas, with a more rounded shape. The skin is loose enough to peel easily, but not as loose as the Satsuma. Clementine fruit is sweet, juicy, and has a wonderful, spicy aroma.

Clementines are not as cold hardy as Satsumas, but do well in warmer locations of the lower foothills between 400 and 800 feet. The leaves are usually smaller and narrower than Satsumas, resembling willowleaf mandarins. The foliage is also aromatic.

Regardless of what you call them, mandarins make great trees for yards, with a wonderful fragrance and beautiful fruit to brighten dreary winter days. And the fruit is sure to be enjoyed by all! There are many mandarin varieties produced in the foothills,

with harvest periods ranging from November through February. So sit down, peel a mandarin, and enjoy the citrus taste of the foothills!



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TRAINING AND PRUNING FRUIT TREES

There are many ways to train and prune fruit trees – no single method is right for all situations and needs. One important consideration is tree size. Many people prefer small trees because they are easier to manage and harvest and more fruit types can be grown in a limited space. Other people prefer large trees because they provide shade and more fruit. For many backyard gardeners, ease of management and variety of fruits are increasingly preferred over shade.

Summer vs. Dormant Pruning

No matter which training method you choose, use summer pruning to train young trees and shorten the time to full fruit production. On mature trees, summer pruning involves mainly: 1) removing vigorous, upright shoots that are not needed to create permanent branches and 2) heading shoots to control tree height. Summer pruning is done in both spring and summer. When useful, bend and stake any shoots of young trees that you want to grow in a different direction during the spring and summer. Bending branches hastens branch development compared to removing or heading those in undesirable locations and waiting for a new branch to form.

If trees received appropriate summer training and pruning, far less dormant pruning is necessary. However, the absence of leaves provides a clear view of the framework of the tree, so thin or head any branches that were not adequately summer pruned.

When you dormant prune, it is preferable to prune stone fruits in late February to early March rather than in the fall or early winter. Pruning wounds made late in the dormant season heal faster than those made earlier, allowing less time for disease organisms to infect the wound; also, there is less rain after February. Furthermore, spores of many organisms causing branch diseases are more prevalent with early season rains than later. This is especially true with Eutypa disease, which infects apricots (and grapes) and causes severe gumming and branch dieback, so it is especially important to prune apricots late in the season. Apples and pears can be safely pruned at any time.

Genetic Dwarf Trees

Genetic dwarf trees usually produce very short internodes (the space on a shoot between two leaves). These trees make beautiful landscape shrubs that are easily managed and provide adequate amounts of fruit. Trees grow to 8 to 10 feet tall and wide. Excellent varieties are available in peaches, nectarines, and citrus, and more are being developed for other fruit types. Lower fruiting wood of genetic dwarf trees, especially peaches and nectarines, tends to quickly die due to shading by the dense growth, but trees are small, so production of fruit on the extremities of trees is not a serious problem. Pruning mainly involves thinning branches to open up the canopy and cutting back to maintain tree height and spread. Size controlling pruning cuts can also be made; this should be done by pruning to lateral branches rather than heading.

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Division of Agricultural Sciences, University of California, U.S. Department of Agriculture and County of Sacramento cooperating

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Full-Sized and Semi-Dwarf Trees

Full-sized trees are those on standard or semi-dwarfing rootstocks. Full-sized trees can grow to 25 to 30 feet tall. Even semi-dwarf trees often grow to 15 to 20 feet, which is still too tall for most backyard situations. Truly dwarfing rootstocks are being developed for most fruit species, and an excellent selection of small growing semi-dwarf apples is usually available. As will be discussed later, both standard and semi-dwarf trees can be pruned to remain relatively small.

Open Center. The open-center or vase-shaped system is most commonly used on almond, apricot, cherry, fig, nectarine, peach, pear, persimmon, plum, pomegranate, and prune. Many apple and pistachio trees are also trained to this system. With this method, the center of the tree is kept free of branches and vigorous upright shoots in order to allow sunlight to reach lower fruiting wood.

To create an open center tree, in late April of the first growing season select three or four shoots that will become the primary scaffold branches (main structural branches) and pinch back all other shoots to 4 to 6 inches. When possible, the scaffold branches should be several inches apart vertically and they should be distributed evenly around the trunk. In about early June, pinch back or head the selected scaffold branches to 2 to 3 feet to promote side branching and the development of secondary scaffold branches. Also, continue to pinch or head back unwanted branches, but small lateral shoots are left for fruiting and shade. The unwanted branches are removed later, but provide shade for the trunk and main branches of young trees. If summer pruning was not done, or was insufficient, create the open center during the dormant season (Fig. 1). Continue to develop secondary scaffold branches in subsequent growing seasons.

Do not select scaffold limbs that are directly above one another; remove one or the other. Avoid upright limbs with narrow, acute angles from the trunk or main limbs because they tend to be poorly attached. Flat or horizontal limbs should be avoided for scaffold limbs, but they can work if new shoots coming from them are directed upward and outward. For most species, angles for limb attachments of about 45 degrees are desirable. If the tree grows poorly the first year, severely prune primary scaffolds to three or four buds to promote vigorous growth the next year, and correct the causes of the poor growth.

Cherry, plum and pear produce very upright growth and the scaffolds should be bent outward or cut back to outside lateral branches to provide tree spread. Other trees, like apricots, peaches, and almonds, have a spreading growth habit and tend to produce lateral branches without heading. With these varieties it is often necessary to remove flatter-angled branches and leave upright laterals, thus maintaining the upward, outward growth pattern.

Pruning of mature open center trees involves keeping the center free of vigorous, upright shoots, reducing tree height, and thinning out branches to reduce crowding. For peaches and nectarines, one-year-old lateral fruiting branches should be selected to originate close to main branches and these fruiting branches should be thinned (one-third to half of them can be removed) and headed by one-third if they are long.

Central Leader. Central leader training is often used for apples and sometimes for pears and Asian pears. It is used because these species naturally tend to grow this way. In this method, trees are kept shaped like Christmas trees, with lower branches wider than upper branches. Therefore, instead of sunlight reaching lower fruiting wood through the center, as with the open center method, it reaches lower wood from the sides. For young central leader trees, it is important to establish and maintain the dominance of the central leader. This is done during spring and summer by heading back (and later removing) or bending down any shoots that grow upright and compete with the central leader. Create the first whorl of four lateral branches by tying or staking branches outward, just above horizontal. Late in the first growing season or early in the second season, create the second whorl of four branches, offset from the first whorl, by tying or staking branches and always maintaining the dominance of the central leader. Then create the third and fourth whorls. Avoid bending branches directly over one another and maintain lower branches wider than upper branches.

Some side branching of these main lateral branches should be encouraged. However, vigorous, upright shoots are removed or headed back to only 3 or 4 buds throughout the growing season. Heading these shoots creates fruit-bearing spurs. Heading also creates more vigorous shoots; simply remove these shoots or prune them back again to create more spurs.

“Fruit Bushes”. Fruit bushes are standard (full-sized) trees or trees on dwarfing rootstock that are kept small by frequent summer pruning. Pruning begins in about late April or early May of the first growing season, when new growth is about 2 feet long (Fig. 2). At this time, cut the new growth in half with hedge shears. In about June when the subsequent new growth is about 2 feet long, cut that new growth in half. The new growth may need to be cut once or twice more. With all the heading cuts, there can be an excess of branches, so be sure to thin them out a bit (remove some shoots) to allow sun to reach the lower branches. Prune out additional crowding branches in the late dormant season when they are more visible.

In the second year, continue cutting new growth in this manner until the trees reach 6 to 7 feet, at a height at which you can easily prune the top. Pruning in subsequent years involves cutting off any shoots above the tree’s permanent height, thinning crowding branches, and removing non-productive fruiting wood during bloom when this wood is visible. Avoid heading cuts during the dormant season; this stimulates growth.

Pruning Overgrown Trees

Many people have one or more large, neglected fruit trees in their yards. The far majority of fruit from these trees must be picked using ladders, and much of it is even higher. It is very difficult to prune, spray, or thin the fruit in these trees, and high branches often break due to the weight of the fruit. Diseases or borers often invade these trees, and you must assess whether it is worth bringing the tree height down or simply removing the tree and planting a new one. In general, where a large tree is desired it is best to use a shade tree rather than a fruiting tree unless you are able to manage a large fruit tree.

If you decide to work with the tree, there are three main ways to prune it: 1) maintain the tree height and make mostly thinning cuts, 2) reduce the tree height slowly over about a three-year period, or 3) drastically cut back all main branches but one. With more extreme methods where large branches must be cut, wait until February or March – even into the flowering period – in order to allow quicker healing and to reduce the chance of disease organisms entering large pruning wounds during winter rains. Do not paint wounds with anything except white paint. When heading cuts are necessary, if possible cut back to a lateral branch at least one-third the thickness of the branch being cut. Also, if pruning results in exposure of branches to prolonged periods of hot afternoon sun, paint them white with tree whitewash or with a 50:50 mixture of interior white latex paint and water.

1. Maintain the tree height and make mostly thinning cuts. This method assumes that the tree is structurally sound and not much taller than you are able to easily manage with an available ladder. If the tree has been neglected many branches will need to be removed, especially high in the tree. Thin out enough branches to allow sunlight to penetrate to lower wood, but don’t create such big gaps that main branches become subject to sunburn; paint them if necessary. Remove any branches growing beyond the height you are able to pick the fruit. By keeping the tree at this height, it will produce new, vigorous shoots – especially on the top of the tree. These must be removed each year, preferably through summer pruning.

2. Reduce the tree height slowly over about a three-year period. This approach can be successful with appropriate follow-up pruning, especially summer pruning. Determine how tall you would like the permanent structure of the tree to be, and reduce the height by one-third each year for three years until the final height is reached. Vigorous shoot growth is inevitable, so it is essential to remove or head many of these shoots once or twice in the summer to avoid shading lower fruiting wood. Also, thin out branches as needed to allow sunlight penetration.

3. Drastically cut back all main branches but one. This is an extreme method of reducing tree height in a single season. Not all trees are capable of resprouting from large lower branches. Apples and pears will usually work, but old stone fruit trees may not effectively resprout because lower buds may not be able to push through the thick bark. Also, there are often no small branches or twigs low in these trees from which to

produce a new framework. Another concern is that some backyard trees have no main branches below 6 to 8 feet. Such trees are better off pruned conventionally or removed, since the only major cut low in the tree leaves only a stump, which may not regrow.

Main branches are cut with a saw by first creating a deep cut on the underside (to prevent bark splitting) and then removing the limb with a cut on the upper side. If possible, cut above one or more lateral branches – even if they are small branches. Head or thin these branches as needed; they, along with shoots arising from buds on the main branches, will form the framework for the new, small tree. To prevent sunburn, all exposed main branches must be whitewashed.

Because this method removes so much leaf area but maintains a large root system that must continue to receive products of photosynthesis (carbohydrates), it is important to leave one smaller main branch or a large side branch unpruned. This extra branch is then removed the following year, after new branches have formed from the main branch stumps. Follow-up summer and dormant pruning is essential to reform the tree in the desired manner.

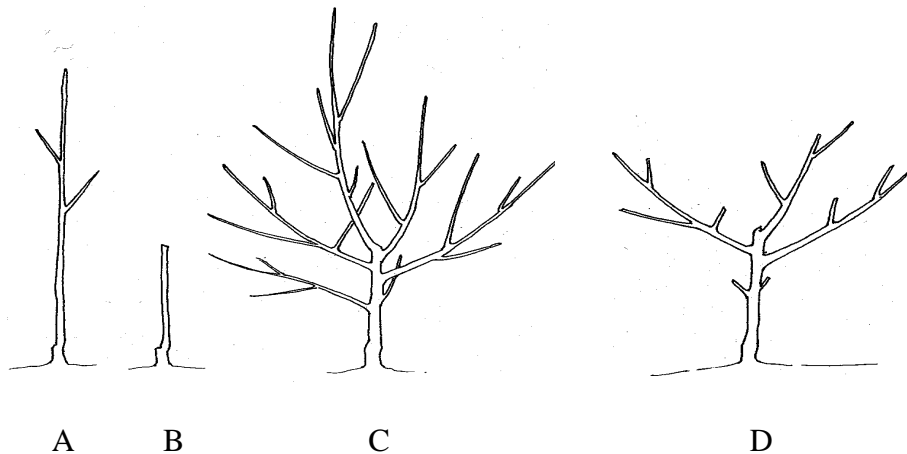


Figure 1. Creating an open center tree. A. Bare root tree just planted. B. Tree headed after planting. C. Growth after one season. D. Tree pruned after one growing season. Further development would have been possible if tree was summer pruned.

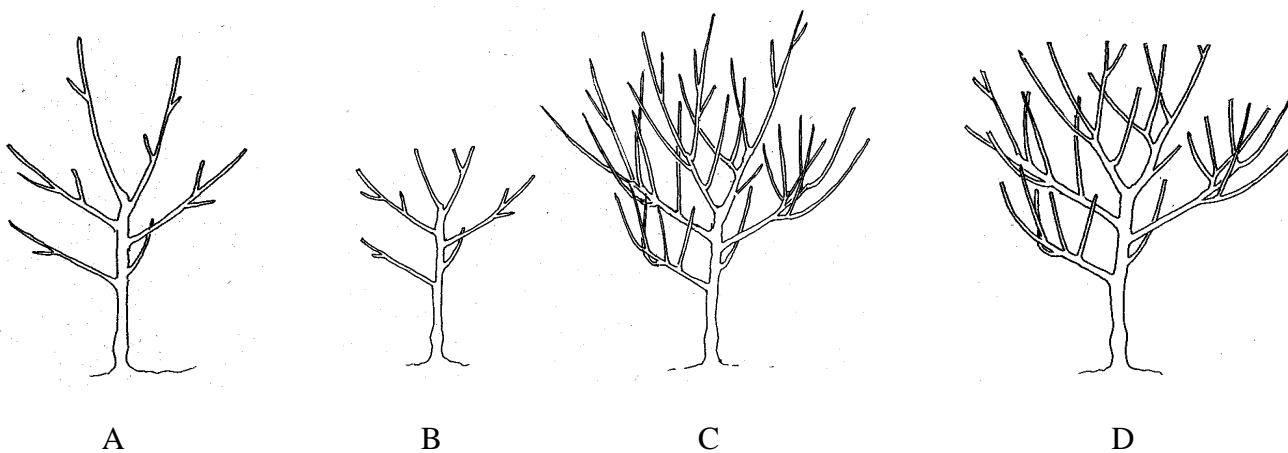


Figure 2. Creating a fruit bush (leaves removed to show structure). A. New growth from trunk in May. B. About half of new growth removed with hedge shears. C. Additional growth in June. D. About half of additional growth removed with hedge shears. Additional new growth may require pruning 1 or 2 more times. Continue each year until tree is at desired height, after which all new top growth is removed through spring and summer.

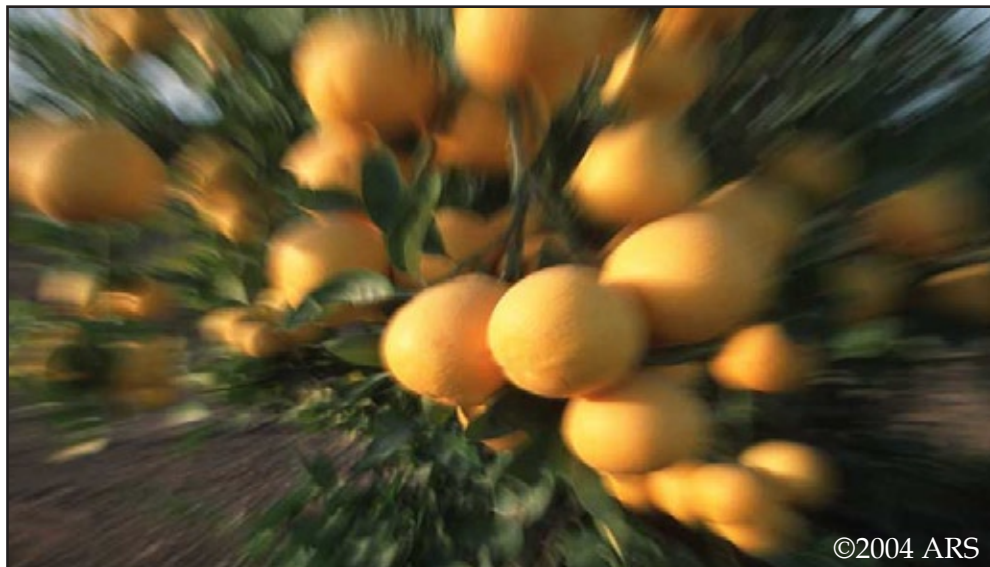
January, 2000. Written by Chuck Ingels (Farm Advisor) and UC Master Gardener Eleanor Dong. Illustrated by Walter Dong.

Tree Fruits: Organic Production Overview

HORTICULTURE SYSTEMS GUIDE

***Abstract:** This guide is an overview of issues relevant to commercial organic production of temperate zone tree fruits and, to a lesser extent, tree nuts. It includes discussions of marketing and economics, orchard design, and cultural considerations, including crop varieties, site selection, site preparation, soil fertility, weed control, and pest management (insects, diseases, and vertebrates). It raises questions for the grower to consider in making decisions about orchard and enterprise design. Lists of electronic and print resources offer further, more detailed information.*

By Guy K. Ames and George Kuepper
NCAT Agriculture Specialists
Revised September 2004
By Ann Baier
Reviewed by Martin Guerena
NCAT Agriculture Specialists
September 2004
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A note about Organic Standards: Included in this publication are references to the organic standards authorized by the USDA's National Organic Program, www.ams.usda.gov/nop. Organic producers should verify with the appropriate certification bodies that their practices and any materials they intend to use are compliant with applicable standards for their intended markets. This is especially true if those markets are international, where there may be additional production and labeling requirements.

INTRODUCTION

This publication focuses on production and marketing of organic fruits and nuts, highlighting a systems approach to orchard production and farm management. Not intended as a comprehensive production guide for individual fruit crops, this publication introduces key production issues that merit consideration in any specific crop or production region. As noted below, ATTRA has other publications for specific fruit and nut crops. General information on cultural practices for fruit production (choosing varieties, spacing, pruning, training, irrigating, harvesting, postharvest handling, etc.) is relevant to both organic and conventionally managed operations, and it is widely available from the Cooperative Extension Service, nurseries, and in horticulture literature.

ORGANIC FRUIT PRODUCTION

Organic production is defined by USDA's National Organic Program (NOP) as "A production system that is managed...to respond to site-specific conditions by integrating cultural, biological, and mechanical practices that foster cycling of resources, promote ecological balance, and conserve biodiversity."

Organic fruit production involves more than simply excluding synthetic pesticides and fertilizers. Benign neglect does not meet NOP standards for production. Organic agriculture is an integrated approach to active and observant management of a farming system. It begins with good soil management for nutrient cycling, productivity, and tilth. It involves an integrated, preventative approach to pest management to protect the health and productivity of the orchard.

ATTRA has additional information on organic fruit production and organic agriculture. Please refer to the list below for guides to production of specific fruit crops. Many of these publications discuss the transition from conventional to organic farming, as well as how to become certified, write an organic systems plan, and develop markets or value-added enterprises. See the ATTRA Web site, www.attra.ncat.org, for a complete list of publications, or call 800-346-9140 to request a current Publications List.

ATTRA Publications on Organic and Low-Spray Fruit Production

- Organic and Low-Spray Apple Production
- Considerations in Organic Apple Production
- Organic Pear Production
- Organic Blueberry Production
- Organic Culture of Bramble Fruits
- Organic Grape Production
- Strawberries: Organic & IPM Options
- Pawpaw Production
- Persimmon Production
- Organic and Low-Spray Peach Production
- Low-Spray & Organic Plum Production
- Sustainable Pecan Production
- Overview of Cover Crops
- Farmscaping to Enhance Biological Control
- Biointensive IPM
- Sustainable Soil Management
- Alternative Soil Testing Laboratories
- Alternative Soil Amendments
- Foliar Fertilization
- Sources of Organic Fertilizers and Soil Amendments



MARKETING AND ECONOMIC CONSIDERATIONS

To plan for economically successful enterprises, farmers must design their fruit production systems to match their marketing strategies. Good fruit production alone does not lead to a successful enterprise. Profitability depends on a combination of production volume, quality, size, and a reliable marketing strategy. Marketing channels range from direct markets to wholesale shippers. Growers must understand what each of their customers wants and be prepared to meet the expectations of the markets they intend to reach. For example, at farmers' markets, customers seek good tasting fruit at or near the peak of ripeness for prompt consumption, but supermarket distributors demand that fruit be uniform and shippable. It is important to market in an appropriate niche, one where the production of your operation can consistently meet the buyers' expectations of volume, quality, and timing.

Good production and good quality do not guarantee good returns.

My late friend, farmer, and master machinist Grover Parsons recounted how he planted 10 acres of apricots in San Juan Bautista, California. He chose the best-tasting variety, Royal Blenheims. He cultivated them organically, but that was before there were organic standards for market differentiation and premium pricing. The variety was also well-suited to the climate and soil. They grew beautifully and began producing good yields of excellent fruit. He harvested the apricots at the appropriate time and sold them to a local buyer. With each successive season he found the price more and more discouraging; it did not adequately compensate him for his work. He got on his tractor and took out the orchard—all but a few trees along the fence-line. Those trees were still providing him with good fruit for home use decades later.

- Ann Baier

Premium pricing can be critical to the viability of organic fruit operations, because production costs are often higher than those for conventional orchards. Organic pest control, particularly labor costs for hand thinning and weed control, is generally more expensive than conventional practices. Yield and quality can vary widely, depending on the growing season and management practices. In the past it may have been true that organic yields and pack-out rates (the percent of

Yield and quality can vary widely, depending on the growing season and management practices.

marketable fruit) were lower than in conventional production. Today, however, those differences have narrowed, and yields in some organic production systems can match or exceed those of conventional systems. To achieve good yields, organic growers must be prepared to develop innovative production and marketing strategies. Many commercial organic fruit producers, especially family-scale farmers, minimize waste and losses of potential revenue by processing (drying, preserving, or juicing) fruit considered unsuitable for the fresh market. See ATTRA's publication *Adding Value to Farm Products: An Overview*.

There are tradeoffs in every marketing strategy. A successful grower must develop markets in which the price for organic produce adequately compensates for all production costs. Additionally, the marketing process must be compatible with the grower's personality and business skills. The particular combination of components in any grower's marketing strategy will depend on local marketing opportunities as well as the grower's desire to be directly involved in marketing, tolerance for stress, and ability to balance a variety of risk factors. For more information, request the ATTRA publications *Evaluating a Rural Enterprise*, *Keys to Success in Value-Added Marketing*, and *Direct Marketing*.

Cost-Benefit Analysis of Markets

Several certified organic apple growers in the Central Coast region of California sell their culls to Martinelli's, a longstanding locally-based juice company. The company has a low-volume organic juice line that produces a limited number of runs each year, if farmers can time their harvest to match it. Even though the company does not give a premium for organic fruit that goes into their regular juice line, its proximity to the farms, fair payment practices, and good business relations make for a satisfying and cost-effective sale for many organic growers. Although there are organic processors in other parts of the state, the price premium for organic fruit does not always offset the increased transportation costs, volume requirements, hard bargaining, or worry about late payments from more distant organic processors. Being certified organic increases one's marketing flexibility. An organic certificate provides the option but not the obligation to use the organic claim. When it is advantageous, organic produce can be sold as conventional, but never vice-versa.

Cultural practices in fruit production begin with selection of an appropriate site, fruit crop, root-stock, and fruit variety, followed by site preparation (tillage and pre-plant soil amendments) and orchard layout (tree and row spacing). These considerations will largely determine the productivity, health, and efficiency of operations in your orchard over the long term, and they cannot easily be changed once the orchard is established. If you are managing an existing orchard, you will continually need to take stock of its assets and limitations in relation to current markets, and either work within those limits or make plans for some degree of orchard renewal. If you are considering the purchase of an existing orchard, ask the owners about their financial history (production costs and sales records), and research the market to assess the economic feasibility of continuing with the business as it is currently practiced. Once you have made the most realistic cost estimates possible, you can develop a plan to adjust the production system,

revise the marketing plan, or walk away while you still have your shirt.

PLANNING AND PLANTING AN ORGANIC ORCHARD

Site Selection

Fruit trees, like most crops, respond to good soil with vigor and productivity. Trees can successfully produce economic yields on hillsides, rocky soils, and other sites not suitable for frequent tillage. Look carefully at your site and take stock of its soil, slope, and aspect, water infiltration and drainage, frost patterns, maximum and minimum temperatures, length of growing season, distribution of annual precipitation, availability of water for irrigation, proximity of the water table, and wind and air circulation patterns. Most of these are beyond your control, and your planting plan must suit the natural conditions of the site. While farmers may be able to improve the soil over time, they cannot change the subsoil layers, influence the prevailing wind, or modify temperatures to any significant extent.



All the factors regarding site suitability for conventional fruit plantings apply—even more so—to organic operations. While conventional growers may fall back on chemical fertilizers and pesticides to compensate for some poor site decisions, organic growers cannot. Good drainage and air circulation are essential for disease control. The presence of certain weeds and forage species is of particular concern to the organic grower. Bermuda grass, Johnson grass, quack grass, and several other pernicious species can be serious problems to fruit growers and are difficult to control with organic methods once an orchard is established.

An assessment of physical and environmental factors will help the grower determine whether a crop can be grown easily, marginally, or not at all. While someone with a home orchard may consider it worthwhile to cover a lemon tree before each anticipated frost, or to nurse a few apricot trees through Midwestern winters in order to savor the delicious fruits two seasons out of seven, these would likely not be viable commercial enterprises. However, stretching the limits of production within reason can be worthwhile under certain circumstances. For example, subtropical fruits grown in the coastal valleys of California bring a premium for their freshness and novelty, offsetting the expense of the extra care they require. Depending on the crop, harvesting either early or late in the season can also provide a market advantage. While California's San Joaquin Valley is not known for apple production, its warmer spring and summer temperatures can bring the crop to maturity a few weeks ahead of coastal producers. The price premium for first-of-the-season organic fresh-market apples may offset the overall lower crop yields. Fruit grown in its primary growing region may be more difficult to distinguish from the rest of the fruit in the market, and so lose its competitive edge.

Pragmatism is critical in crop and variety selection. The fruit grower must take into account not only factors of yield, productivity, quality, and flavor, but also of marketability. Diversification of varieties and marketing channels is a prudent

strategy. While one farm in California may receive a good return for the fruit from one lone jujube tree, there is no assurance that such a profit can be scaled up to an extensive orchard of specialty

fruits. Conclusions: while the jujube is a tasty and unusual fruit, and the value of fruit from one tree may be substantive, the regional market for

Depending on the crop, harvesting either early or late in the season can also provide a market advantage.

this novelty would not accommodate production from 200 trees. Similarly, in his book *Epitaph for a Peach*, Mas Masumoto describes the wonderful flavor and quality of the Suncrest peach. Yet his family farm substantially decreased their plantings of this variety. It was a practical business decision to plant more of the newer varieties that the current market demands, and keep a smaller block of the sumptuous Suncrests that are more difficult to ship and store. This seasoned fruit grower advises a production and marketing plan that includes a combination of mainstream and specialty varieties.

Fruit Crop and Variety Selection

Because fruit trees are perennial and represent a considerable investment of both time and money, it is important to start by planting your orchard with the optimum varieties for your location and intended markets. Research on the front end can pay the grower back many times over. Information on species and varieties is available from Cooperative Extension, nurseries, and other local growers. Many land grant universities have field stations where they have planted many varieties of fruit trees and gathered data and observations over several years. A visit to such a site can provide you with the invaluable opportunity to see the trees growing, talk with the manager of the experiment station about production challenges such as pests and diseases, and even taste the fruit.

Crop Species Selection

Clearly, the first decision is what species to plant. Is a tree orchard the best use of your land and talents? Or is your site and marketing plan better suited for a somewhat shorter-term investment in smaller plants such as blueberries, caneberries (raspberries, boysenberries, olallieberries, other blackberry varieties), grapes, kiwi, or even

strawberries? If you are sure that you are willing to manage tree fruits and nuts, will your focus be to produce almonds, apples, apricots, avocados, cherries, figs, grapefruit, jujubes, lemons, oranges, pawpaws, peaches, pecans, pears, persimmons, plums, pluots, or zapotes?

Careful consideration of environmental conditions, as well as the locations of markets and suppliers, is of tantamount importance. For example, organic peach production in the East is greatly complicated by the presence of the plum curculio and by greater disease pressure than in the drier climates of the West. In general, the West's arid climate is better for organic fruit production. The small fruits (blueberries, blackberries, raspberries) are easier to produce organically than tree fruits in almost all locations.

The availability of production supplies and markets in your region can be a critical factor in crop selection. Being the only one growing a certain fruit may provide you with a local marketing niche; however, the value of readily available supplies and services should not be underestimated. While some supplies can be easily and cost-effectively shipped by mail, others cannot. Pest management materials such as codling moth pheromone traps can be efficiently shipped from a distant supply company. But how far do you have to drive to purchase boxes and bulky packaging supplies? How far to cold storage, a packing house, distributor, processor, or transportation terminal? Driving several hours to purchase appropriate boxes or to deliver fruit to a broker's cooler can make an otherwise viable enterprise unprofitable.

Careful consideration of environmental conditions, as well as the locations of markets and suppliers, is of tantamount importance.



Photo by Scott Bauer. ©2004 ARS

Variety and Rootstock Selection

Once the question of crop species is settled, the next decision is what variety (or combination of varieties) to plant. Considerations include, but are not limited to:

- harvest season: early, mid, or late season, or a combination of these to achieve a more continuous supply or to ensure a crop during early or late marketing windows
- adaptability to the region: cold hardiness, temperature ranges for optimal growth, requirements for soil fertility or pH
- chill requirements for fruit set and flavor
- water requirements: need for irrigation or protection from waterlogging
- stature: dwarf, semi-dwarf, or standard
- resistance to diseases and pests

- marketability: color, flavor, nutritional value, storage requirements, shipability, uniformity, shelf life – any characteristics that define quality for your customer
- proximity to appropriate markets

You can select for desired characteristics, especially in grafted trees, with a combination of varieties of rootstock and fruiting wood.

Sources of Planting Stock

It is important to get clean planting stock. Buying from reputable nurseries that provide stock certified by state inspectors to be free of diseases and insect pests is best. Organic planting stock is required, if commercially available, for certified organic fruit production. If organic planting stock is not available, organic growers must document their search for organic stock and its lack of commercial availability. Most certifiers interpret the organic standards as requiring organic management of non-organic planting stock for at least 12 months before harvesting a crop that is to be represented or sold as certified organic. With

newly planted tree crops, this is a non-issue, since they generally grow for at least three years before producing a marketable crop.

Type and Size of Planting Stock

The type of rootstock – standard, dwarf, or semi-dwarf – will determine the size of the tree at maturity. Tree size determines the spacing, number of trees per acre, training system, years to bearing, and timing of economic return. Orchard design should reflect the grower’s production and cash-flow goals. For example, standard trees produce more fruit when mature, and initial purchase and planting costs are lower. Smaller trees have higher initial planting costs, since more trees are needed to achieve density. Dwarf and semi-dwarf trees generally come into production sooner. Smaller trees simplify many field operations, including pruning, grafting, thinning, pest management, and harvest. Efficiency and safety are greater when a majority of operations can be accomplished from the ground as opposed to on ladders or by climbing. Weeds are less of a problem in the shade of a densely planted orchard.

Orchard design should reflect the grower’s production and cash-flow goals.



Photo by Jake Levin

Depending on the species and variety, bareroot trees are often the most practical form of planting stock to ship, and the most economical to purchase. This is a good option for deciduous trees. Other varieties, such as citrus, must be purchased in containers. Given the option of different sizes of bareroot trees, some walnut growers say that investing in a 1-inch tree over a ¾-inch tree is worthwhile, because the larger trees grow more vigorously. An experienced apple grower who produces without irrigation beyond the first year, however, stated his preference for 5/8-inch bareroot trees, which have a good balance of roots and are neither too big nor too small.

Disease and Pest Resistance

Genetic resistance refers to inheritable traits that enable a plant to inhibit disease and resist pest damage. A very important control measure for organic growers is to choose cultivars that are resistant to the pests – especially the diseases – most prevalent in their areas. In some cases, such as that of bacterial spot in peaches, cultivar resistance is the best or only control for a particular disease. A cultivar may be quite resistant to one disease but still susceptible to another. Prima apples for instance, are very resistant to scab but very susceptible to cedar-apple rust. A planting stock resistant to a particular pest provides only relative resistance, not absolute immunity. A moderately resistant or tolerant variety may show symptoms of the disease but exhibit little to no reduction in yield.

Disease resistance must be weighed against other advantages. For example, walnut growers in the coastal regions of California have lost large numbers of trees in recent years to “black line,” a fungal disease for which there is no treatment, only resistance. Payne variety is susceptible and Chandler is highly resistant to this disease. (Some say that Chandler also appears to suffer lower damage levels from codling moth and walnut husk fly, the other common walnut pests in the region.) A trade-off is that Paynes mature sooner and can be harvested earlier in the fall, whereas Chandlers come in at least a month later when early rains can hinder harvest operations and

make field preparations for planting a winter cover crop difficult or impossible.

While no fruit trees are resistant to insects that damage their fruit, it is possible to find stock that is resistant to insects that feed on other parts of the plant – *Phylloxera*-resistant grape rootstocks, woolly aphid-resistant apple rootstocks, and nematode-resistant peach rootstocks, for example. As important as this resistance is, there is no cultivar of any fruit species with multiple insect pest resistance; therefore, an integrated pest management plan is necessary to protect fruit plants

It will be important to identify the most troublesome pests for your crop and region in terms of frequency of incidence, severity of damage, cost of control, and economic consequences of the damage.

from a complex of several pest species. It will be important to identify the most troublesome pests for your crop and region in terms of frequency of incidence, severity of damage, cost of control, and economic

consequences of the damage. Then seek out varieties that are resistant to those key pests and take into account any trade-offs you may make with other desirable characteristics, including seasonality, productivity, and flavor. Substantial crop- and variety-specific information on pest and disease resistance is available on the Web site of the University of California IPM project and other university pomology departments. Be sure to check with local suppliers of planting stock, and talk with other growers in your area about what has worked best for them.

Site Preparation

Important considerations in site preparation include alleviating soil compaction, enhancing fertility, adjusting soil pH, and managing weeds, pests, and diseases. Attention to the details of site preparation can help reduce weed and disease problems and assure a vital planting through soil improvement. What needs to be done depends on the previous use of the land, including crops grown, current vegetation, and the presence of pests and diseases. Many growers rip or chisel the soil to loosen layers of compaction before they plant a new orchard, since deep tillage will be disruptive once the trees are established.

Before establishing an orchard, it is important to adjust the soil pH to best suit the crop you’ve

selected. Soil tests can assess current soil conditions, including pH, mineral levels, and their relative proportions. Traditionally, pH has been adjusted through applications of lime (to raise the pH) or sulfur (to lower pH). Most fruit plants perform best around pH 6.5, although they tolerate a pH range between 5.5 and 7.2. Blueberries are an exception. They require an acid soil—ideally pH 4.8 to 5.2. Soil test results help to guide applications of soil amendments such as compost, lime, gypsum, or other rock powders, to provide good soil conditions that meet the nutritional needs of the orchard.

In general, fruit crops do not require highly fertile soils for good production, though this varies with the species. Highly fertile soils, rich in nitrogen, can promote too much vegetative growth at the expense of fruiting in trees such as apples. A nutritionally balanced soil, proper soil pH, and plentiful organic matter are the fundamentals of an organic fertility management plan for fruits. Pre-plant soil improvement for organic fruit plantings usually involves some combination of cover cropping and applications of compost, natural minerals, or other organic fertilizers.

Weed Management Prior to Orchard

Establishment

It's easier to manage weeds before an orchard is established. Cover crops (see ATTRA's *Cover Crops & Green Manures*) produce a thick stand that will shade or choke out weeds. Combined with a well-planned sequence of tillage, cover cropping is an effective pre-plant weed suppression strategy that also contributes to soil fertility and stable humus. The basic strategy begins with



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plowing under or disking the existing vegetation, ripping or deep chiseling to loosen compaction, planting a cover crop to suppress weed growth, mowing down and tilling under the cover crop(s), and finally planting the fruit crop. Several cover crop and tillage sequences may be necessary before planting.

Specific cover crops and management strategies vary with location and purpose. The two cases below raise the kinds of questions you need to ask to choose an appropriate cover cropping system. The cover crops you choose for site preparation (before planting the orchard) may be entirely different from those you want once the orchard is established.

Bart Hall-Beyer, co-author of *Ecological Fruit Production in the North* (1), provides one example of how cover crops can be used to suppress weeds in the growing season prior to fruit crop establishment. His program consists of fall plowing, to allow the sod to rot, then disking as soon as the soil is dry in the spring, followed by harrowing every 10 days for at least one month to kill germinating weeds. He next incorporates compost and mineral nutrients and seeds buckwheat as a smother crop. He then tills the buckwheat into the soil after it has started flowering but before seed-

Attention to the details of site preparation can help reduce weed and disease problems and assure a vital planting through soil improvement.

set. Hall recommends additional cultivations at 10-day intervals, followed with rye as a fall cover crop. The rye is incorporated the following spring and the fruit crop planted.

In the Mid-South, researchers at the Kerr Center for Sustainable Agriculture in Poteau, Oklahoma, evaluated a number of cover crops for weed suppression on heavy soils.(2) They converted pasture land to horticultural production, using rotations of cover crops and tillage. By this method, they virtually eradicated Bermuda grass from the fields in one to two years. Among their general observations are the following.

- Dense warm-season cover crop plantings of several species demonstrated a high degree of weed suppression, whether close-drilled in 6-inch rows or planted on wider 32-inch rows and row-cultivated.
- The length of the warm season may allow more than one cover crop to be grown in succession. Some cover crops may also be cut and allowed to regrow.
- Legume cover crops of purple hull peas (cowpeas), crotonaria, and sesbania all demonstrated good-to-excellent weed suppression, while supplying nitrogen and biomass to the soil.
- Of these, sesbania produced the most biomass and was the most effective weed suppressant. When cut with a sickle-bar mower at flowering, it regrew well and continued to suppress weeds. It is very drought-tolerant. Seed cost and delivery, however, were quite high. If allowed to re-seed, sesbania can create a moderate weed problem the following year.
- Crotonaria (sun hemp) was a better nitrogen producer, but a less effective weed suppressant than sesbania. It, too, can be cut at flowering with a sickle-bar mower and allowed to regrow. Like sesbania, it is very drought-tolerant. The cost of seed can be high. Crotonaria seed is toxic – especially to birds – and the plants should not be allowed to go to seed.
- Because crotonaria and sesbania are quite fibrous, they should be mowed with rotary or flail mowers prior to soil

incorporation.

- Cowpeas produce somewhat less nitrogen than crotonaria, and less biomass than either sesbania or crotonaria. They are, however, less fibrous and, therefore, decompose faster.
- Allowing cowpeas to flower and produce mature, dry seed prior to incorporation creates an inexpensive, self-seeded succession cover crop.
- Sudan grass proved the most effective of all warm-season weed suppressants. It can be flail or rotary mowed several times if regrowth is desired.
- Winter cover crops can be planted in rotation with warm-season cover crops. A combination of grain rye and hairy vetch was the most effective in this location. Winter peas and oats, and winter wheat – often grown in combination – also have good competitive ability.

Soil Solarization

Soil solarization is placing transparent plastic



Photo by Gary Kramer. ©NRCS 2004

films on moist soil to capture solar energy. Solarization takes four to eight weeks to heat the soil to a temperature and depth that will kill harmful fungi, bacteria, nematodes, weeds, and certain insects in the soil. Solarization can be a useful soil disinfestation method in regions with full sun and high temperatures, but it is not effective where lower temperatures, clouds, or fog limit soil heating. Other disadvantages of solarization as a weed control method include its expense and disposing of the plastics. Solarization is most commonly used in smaller areas, such as greenhouses and nursery beds, though it has been used experimentally to treat orchard soils, either prior to planting or during establishment. Experiments are underway to evaluate using biodegradable spray mulches for solarization. Researchers emphasize that solarization should be seen as just one component of an integrated pest management system, rather than as a “stand alone” technology. A University of California Cooperative Extension leaflet (No. 21377), “Soil Solarization: A Nonchemical Method for Controlling Diseases and Pests,” details the technique.(3) The Web site www.uckac.edu/iwgss provides links to current research and publications on solarization.

harvest operations. While the specific spacing and training of trees will largely depend on the species, the following questions offer general considerations that will save time, resources, and expenses throughout the life of the orchard.

- What is the lay of the land? Which way does the water run? What is the angle of the sun during different seasons? How will these affect the movement of both water and air, and in turn, temperature and humidity levels, crop ripening, and incidence of diseases and pests? Do the rows need to be planted on the contour for soil conservation or to capture limited seasonal moisture? Or should they be sloped to drain excess moisture? Given the degree of slope, which direction will provide the greatest safety for operating equipment and ease of harvesting ?
- What are the diseases and pests that affect this crop in this region? What are their life cycles? Alternate hosts? Natural enemies? What conditions favor their growth and severity? What design strategies might promote or reduce these conditions? Would a certain orientation of the rows provide better expo-

Orchard Layout and Design

Orchard layout influences the long-term health of the trees and the ease of field operations such as pruning, irrigation, fertilization, and weed and pest management. Everything is related: the decisions you make about the space between rows and between trees in the row will have an impact on everything from disease management to



Photo by Randall Smith©2004 ARS

Researchers emphasize that solarization should be seen as just one component of an integrated pest management system, rather than as a “stand alone” technology.

sure to the sun or better air circulation? Will you rely on seasonal pruning to maintain an open canopy to increase air flow through the foliage and sun to the fruit?

- What equipment will you use for field operations? Consider all possible tasks, including

planting, mowing (or incorporating orchard floor vegetation), cultivation, pruning, irrigation, application of materials for pest management, and fruit harvest. Be sure that your row spacing is adequate to allow entry and maneuverability of any tractor, trailer, spray equipment, string trimmer, wagon, wheelbarrow, or hand cart that you plan to use.

- What crop density do you seek? How soon after planting? The decision will depend on the species and stature of your trees, the cost of purchasing and planting them, the years to maturity, the prevalence of weeds, and other considerations. Using close in-row spacing or double rows of trees may complicate weeding in the first year or two, but thereafter shading will greatly reduce the need for weeding the inter-row. Some farmers plant slower-growing trees (such as walnuts) using closer spacing, then remove every other tree when they reach a certain maturity. The estimated benefits of earlier harvests must be considered against the costs of planting, managing, and eventually removing the trees. Alternatively, annual crops can be grown between immature orchard trees.

MANAGING AN ESTABLISHED ORGANIC FRUIT ORCHARD

Orchard Floor Management/Cover Crops

The orchard floor – the tree rows and alleyways – can be managed in a variety of ways, using tillage or mowing with cover crops, grazing, or mulching (described in detail in the **Organic Weed Management** section). A system that provides full ground-cover provides the best protection against erosion. Some fruit growers have practiced “clean cultivation,” eliminating vegetation

A bare orchard floor is prone to erosion, gradual depletion of organic matter, increased soil compaction, and reduced water infiltration.

throughout the orchard, but this system has many disadvantages, even if accomplished with allowed tillage practices instead of organically prohibited herbicides. A bare orchard floor is prone to erosion, gradual depletion of organic matter, increased soil compaction, and reduced water infiltration. It’s also difficult to move equipment through the orchard in wet weather. However, a ground cover that is actively growing in the summer uses up water. This is a severe disadvantage in irrigated orchards where water is limited and expensive.

Orchard floor management can control erosion, improve the soil, and provide beneficial insect habitat.

- Where they are adapted, orchard grass, fescue, and other cool-season grasses are practical because they go dormant during the heat of the summer, minimizing competition with the fruit crop for water. With proper fertility management, these grasses can also provide plentiful mulch. Likewise, grasses are a good choice in apple orchards, for example, where the excess nitrogen provided by legumes can actually reduce fruit yields.
- Many warm-season legumes are deep-rooted and compete with the trees for water. Normally, they should not be allowed to grow under the tree canopy. However, leguminous ground covers can provide significant nitrogen to fruit trees or vines.⁽⁴⁾ Grass and legume ground covers alike promote water infiltration and hold the soil in place during the rainy season. Ground covers help maintain and increase soil organic matter, which increases the soil’s ability to retain moisture. Cool season legumes, such as fava or bell beans, vetches, and clovers, also can achieve these goals.
- Planting subterranean clover into established orchards can provide mulch, fertilizer, between-row ground cover, and beneficial insect habitat. This clover reseeds itself in early summer and dies back during the hottest part of the growing season, leaving a relatively thick, weed-suppressive mulch. This system is used in apple and peach orchards in Arkansas ⁽⁵⁾ and for a variety of orchard crops in California ^(6, 7, 8, 9), but not where winter temperatures regularly drop below 0°

F. Subterranean clover can provide habitat for such beneficial insects as ladybeetles, syrphid flies, big-eyed bugs, soft-bodied flower beetles, and other predators.

Crop Rotation

In an organic orchard, crop rotation does not mean changing the economic crop itself, but diversifying the vegetation that grows around the fruit crop. California organic almond farmer Glenn Anderson describes how important maximum plant diversity is within the orchard and in the surrounding vegetation. He takes advantage of every practical opportunity to diversify vegetation: the orchard floor grows cover crops; the landscaping around the family home situated in the midst of the orchard provides shelter and food for a variety of beneficial species; the roadway, farm perimeter, and even the paths of the irrigation lines provide habitat for these beneficials. Research studies confirm the positive effects of organic practices on beneficial insects. Several articles compared yields, pest and beneficial insect populations, and water and air quality factors on Anderson's farm to those of his brother's adjacent, conventional almond farm (10) and found favorable results with organic practices. Mr. Anderson gives credit for the health of his orchard to the host of creatures that contribute to ecological balance on the farm. He believes that all the trees, shrubs, and plants he encourages help sustain beneficial insects, spiders, bats, and birds within and around the orchard.(11)



Fruit bats help disperse seeds and pollinate plants.

Photo by Henry Groom

The USDA National Organic Program Final Rule defines crop rotation in 7 CFR § 205.2 as "The practice of alternating the annual crops grown on a specific field in a planned pattern or sequence in successive crop years so that crops of the same species or family are not grown repeatedly without interruption on the same field. Perennial cropping systems employ means such as alley cropping, intercropping, and hedgerows to introduce biological diversity in lieu of crop rotation." According to 7 CFR § 205.205 Crop Rotation Practice Standard, the benefits of rotation are to "(a) Maintain or improve soil organic matter content; (b) Provide for pest management in annual and perennial crops; (c) Manage deficient or excess plant nutrients; and (d) Provide erosion control."

Cover Crops

Steps and considerations for selecting and managing a ground cover:

- State your objectives in order of priority. For example: suppress weeds, break up soil compaction, add organic matter to the soil (increase tilth, water infiltration rates, and water-holding capacity), enhance soil fertility (fix nitrogen), attract and sustain beneficial insects, serve as a trap crop for pests.
- Take into account the climate, rainfall pattern, soil type, and potential for soil erosion.
- Describe desired growth patterns and characteristics: Does this cover crop have a tap root? Will it regrow if mowed? Does it fix nitrogen? How much biomass does it produce? Is it fibrous? How long will it take to break down? Will I need to mow or chop it to speed its decomposition? When should I incorporate it? Will it reseed itself? What is its potential to become weedy if it goes to seed? Does it attract insects? What kinds? Will it serve as beneficial insect habitat? Is

The functional benefits of every kind of crop rotation and diversification help break weed and disease cycles.

it a host for pests? Can it be used as a trap crop?

- Consider planting techniques and timing: When and how should I plant a cover crop? How can I manage its growth for production of organic matter and nitrogen fixation? Are there seasonal weather constraints to getting equipment into the field? What methods provide the best germination rate for the effort – broadcast, drilled, frost-seeded (the technique of broadcasting seed so that it is incorporated by the motion of the soil freezing and thawing)? What equipment do I have available – disc, broadcast seeder, seed drill, flail mower, chisel plow, spading machine? What is the seed cost? Do I need to inoculate it with *Rhizobium* bacteria to increase nitrogen-fixing nodulation?
- Is the best cover crop for my situation a single crop, a mixed seeding, or a series of different cover crops?

The UCSAREP cover crop resource page includes a guide for selecting the right cover crop for your purpose: www.sarep.ucdavis.edu/ccrop/CCPubs/SelectingCoverCrop.html.

Pest Management

Organic pest management relies on preventative cultural, biological, and physical practices. Organisms – insects, mites, microorganisms, or weeds – become pests when their populations grow large enough to prevent growers from reaching production goals. Integrated Pest Management recognizes that the mere presence of a potentially damaging species does not automatically mean that control actions are necessary. Knowledge of pest life cycles and monitoring techniques developed in IPM programs are useful for organic growers as well, because they mirror some of the elements of the organic pest management standard.



Mexican fruit fly laying eggs in grapefruit

The National Organic Program Final Rule 7 CFR §205.206 Crop Pest, Weed and Disease Management Practice Standard reads: “(a) The producer must use management practices to prevent crop pests, weeds and diseases including but not limited to: (1) Crop rotation and soil and crop nutrient practices...; (2) Sanitation measures to remove disease vectors, weed seeds, and habitat for pest organisms; and (3) Cultural practices that enhance crop health, including selection of plant species and varieties with regard to suitability to site-specific conditions and resistance to prevalent pests, weeds and diseases. (b) Pest problems may be controlled through mechanical or physical means including but not limited to: (1) Augmentation or introduction of predators or parasites of the pest species; (2) Development of habitat for natural enemies; (3) Non-synthetic controls such as lures, traps and repellants. (d) Disease problems may be controlled through (1) Management practices which suppress the spread of disease organisms; or (2) Application of non-synthetic biological, botanical or mineral inputs. (e) When the practices provided for in paragraphs (a) through (d) of this section are insufficient to prevent or control crop pests, weeds and diseases, a biological or botanical substance, or substance included on the National List of synthetic substances allowed for use in organic crop production may be applied to prevent, suppress or control pests, weeds, or diseases: Provided, That the conditions for using the substance are documented in the Organic System Plan.”

Three tiers of pest management strategies are described in the NOP Final Rule.

1. First, the producer should use cultural management practices that prevent pest and disease problems. These include multiple components of a holistic, systems approach to organic farm management and crop production.
2. In the second tier of pest management, biological and physical methods provide additional protection and need no justification. These practices build on and complement good cultural practices, but cannot compensate for poor cultural practices.

3. The third and final tier – the last resort – may be applying an allowed material if the first two tiers of response are ineffective and if the conditions for their use are described in the grower's Organic System Plan (OSP). A material response may be necessary under some circumstances, but it will be just one component of an integrated pest management plan that is part of an overall OSP.

Common arthropod pests of fruits include insects (aphids, caterpillars, leafrollers, twig borers, flies, psylla, scale insects, leafhoppers, mealybugs, earwigs, thrips, and beetles) and mites. Identification and preventative management are essential to organic production systems. Identification charts are available from many university Extension Web sites and publications. *Organic Fruit Tree Management* (15) provides a useful list of important fruit pests, their hosts, status (potential impact on various stages of fruit tree growth as well as on crop production and quality), identification (adult, immature/larva, pupa, and eggs), life cycle, monitoring/thresholds, and management. This book was written for fruit growers in the North and may not address the key pests in all other regions. Nonetheless, its approach and outline serve as an extremely useful models for growers developing informed and integrated organic pest management strategies for their orchards.

While there are many other components to insect and mite pest management, in recent years there has been a good deal of research on vegetation management to enhance natural biological control. Approaches to cover crop and vegetation management described by Bugg and Waddington (13) include 1) resident vegetation that harbors beneficial arthropods (insects, mites, spiders); 2) strip management of cover crops to ensure the continuous presence of habitat for both beneficials and pests; 3) insectary mixes of plants attractive to beneficial arthropods; and 4) use of mulch from mowing to harbor generalist predators. There is also increasing evidence that managing vegetation adjacent to economic crops (fencelines, roadsides, etc.) as habitat for beneficial insects has a positive impact on pest management. These areas often include native plants and shrubs that flower at different times of the year, providing sources of pollen and nectar for beneficial arthropods. See the ATTRA publication *Farmscaping to Enhance Biological Control*.

The long-term nature of growing fruit using cover crops and other resident vegetation management can sustain populations of predators, parasites, and other beneficial organisms.(14, 15, 16) There are many possible trade-offs that emphasize the need for careful planning and the importance of research and monitoring.

- Apples and pecans: California apples and Georgia pecan orchards planted in a diverse mix of cover crop species provided habitat and food for an array of beneficial organisms, resulting in a decrease of orchard pests.
- Peaches: Some winter annual broadleaf weeds have been implicated in increased populations of tarnished plant bugs in peach orchards, and dandelions and chickweed can serve as hosts for viruses that affect peaches and apples.(15)
- Walnuts: Two species of ladybeetles were more abundant in an orchard floor where a cover crop was maintained from February to May, and helped keep walnut aphid populations in check.
- Apples: Codling moth infestations of apples were lower where bell beans grew.(13) Bell beans are known for their extrafloral nectaries that help sustain beneficial insect populations even when the flowers are not open. Insect-eating birds can also reduce codling moth populations, but not control them. The development of pheromone mating disruption has been a major breakthrough in the past several years, making organic codling moth management feasible and organic apple production competitive.
- Cherries: In regions of California where the mountain leafhopper transmits buckskin disease, growers should use caution in establishing permanent covers that include cool-season alfalfa and clover species that harbor the leafhopper. This case emphasizes the importance of understanding and carefully considering the pest's life cycle, with respect to the presence of host plants where the pest can reproduce.
- Citrus and avocado: Wind-blown pollens from grasses and trees can be alternate food sources for the predatory mite *Euseius tularensis* in late winter and early spring,

and may, therefore, help build and sustain populations of predatory mites that attack pest species that include the avocado brown mite, citrus thrips, citrus red mite, and scale insects.(13)

- Some legumes are also known to attract hemipterous pests like tarnished plant bugs and stink bugs.(17, 18) Where these pests are a problem, legumes may be less desirable as orchard cover crops, unless they can be managed as trap crops for lygus bugs. Alternatives such as mustards, buckwheat, dwarf sorghum, and various members of the Umbelliferae (carrot, cilantro, dill, fennel, anise, etc.) and Compositae (sunflower and other composites) families support substantial numbers of beneficial insects without attracting as many pests. However, mustards flower and seed early, providing early season food for hemipterans, including stink bugs.

Conversations with several organic farmers reinforce these research findings. Many organic walnut growers plant cover crops that are mixtures of legumes – such as bell beans, vetch, or alfalfa – to produce nitrogen and create a beneficial insect habitat, in combination with cereals that produce organic matter and provide support for the legumes. Growers alternate rows when they mow or disc, intentionally leaving strips of cover crops in the orchard to provide areas with flowering plants that sustain populations of beneficial insects. In any orchard setting it is important to watch for gopher problems. In addition to their many benefits, cover crops can also provide food and cover for gophers.

Disease Management

Disease can be a significant limiting factor in organic fruit production. Diseases may be caused by fungi, bacteria, viruses, nematodes, mycoplasmas, or protozoans. Disorders caused by the weather or by nutrient imbalances (deficiency or toxicity) can create symptoms that look like diseases. Proper identification and preventative management are imperative. For example, boron toxicity or blossom-end rots cannot be cured with fungicides. Cooperative Extension and university Web sites can help in identifica-

tion. The book *Organic Tree Fruit Management* (12) includes detailed descriptions of diseases of fruit crops, including hosts, status (potential impact), symptoms, life cycle, monitoring/thresholds for treatment, and organic management strategies. This book's organic context and perspective are invaluable. Thresholds for action may be distinct in an organic pest management system (in which the impact of a disease organism is considered not only on this year's crop but also in terms of the

future implications for control, potential buildup, and impact on the health of the trees), compared to conventional IPM programs (in which the availability and allowability of pesticides is assumed).

Disease can be a significant limiting factor in organic fruit production

As described in the NOP standard, a combination of cultural controls forms the foundation for a good disease-management strategy. As discussed earlier in this publication, selecting resistant varieties or rootstock is of utmost importance, as is selecting the right growing location. In an established orchard, one can practice good sanitation by cleaning up debris, pruning, and removing diseased plants and disease vectors. Some plants can serve as alternate hosts for diseases. Eastern red cedars, for example, are alternate hosts for cedar-apple rust. Wild blackberries can harbor blackberry rust, and wild plums can foster peach brown rot. A good defense against plant disease is to maintain the crop plants in excellent health and vigor, with sufficient – but not excessive – soil nutrients and moisture.

Many diseases of fruit crops only affect a particular species and variety of fruit. There are, however, some diseases that are common to almost all temperate-zone perennial fruit crops. For instance, because of the relatively soft nature and high sugar content of most mature or nearly mature fruits, fruit rots are common afflictions. Sunlight and circulating air help to dry leaf and fruit surfaces, thereby limiting fungal and bacterial infections. The organic grower can help to minimize fruit rots by allowing good air circulation and sunlight penetration into the interior plant canopy. In tree crops, this would mean proper pruning and training. In brambles and strawberries, reducing plant density helps. In

grapes, adequate pruning and removing leaves that shade fruit clusters is beneficial. All fruit crops need a site that allows good air circulation. Well-timed applications of allowed fungicides can be effective in an integrated disease-control program for mildew and fruit rots in certain fruit crops. See **Applying Materials** below.

Soils can be made disease-suppressive through the addition of significant amounts of organic matter to the soil.

Another problem common to many fruit crops is root rot and intolerance to poorly drained soils. Blackberries, most pear rootstocks, and some apple rootstocks are relatively tolerant of heavy or poorly-drained soils, but even these crops will succumb to persistently water-logged conditions. Blueberries, raspberries, and *Prunus* species (peaches, plums, cherries, etc.) are very intolerant of poorly drained soils and are generally susceptible to root-rotting organisms common in such soils. Even in well-drained soils, blueberries and raspberries are often planted in hills or raised beds. Again, site selection is very important.

Soils can be made disease-suppressive through the addition of significant amounts of organic matter to the soil. This has been most vividly demonstrated in Australia, where liming and cover crops – combined with applications of chicken manure, cereal straw, weed residues, and other materials – are used in avocado groves to control *Phytophthora* root rot. This strategy, known as the “Ashburner system,” is now common practice in many areas where avocados are grown.(19) In contrast, mulching apple trees in humid areas, such as New York, may increase *Phytophthora* root rot.(27)

To identify fruit diseases and their life cycles, please see fruit production resources compiled by the Cooperative Extension Service. Some of the publications in the **Resources** section of this

publication provide an excellent summary of fruit diseases.

Plant Health and Vigor

Maintaining plants in good health and vigor is important in insect pest management. For fruit plants, this adage is more applicable to indirect

pests (those that feed on foliage, stems, etc.) than to pests that feed on the fruit. For instance, an apparently healthy plum tree may set a good crop of fruit, yet lose it all to the plum curculio. That same tree might suffer significant defoliation

by caterpillars early in the season; yet, if it is in good vigor, it can compensate and bounce back quickly – still producing a marketable crop that year. There are some cases where general plant health and freedom from stress do impart a



Photo by Peggy Greb ©2004 ARS

form of “resistance” – not technically genetic resistance – to certain pests. Two examples are apple trees in good vigor that actually cast out invading flathead apple tree borers by smothering them with sap, and plants not suffering drought stress being much less attractive to grasshoppers. For more in-depth information on designing an integrated pest management program for your farming system, please refer to the ATTRA publication *Biointensive IPM*.



Biological Control

Biological control uses living organisms to manage pest populations. When a pest is endemic (not exotic), natural enemies are present, and biological control occurs naturally. The fact that it is occurring may not be noticed by growers. Researchers monitoring certain pests, such as leafminers, have found that pest populations actually increase after pesticide applications kill their natural enemies.

As described above, biological control can be enhanced by cover crops and habitat management. However, where a known pest appears predictably and can be controlled by a specific biological agent, timed releases of beneficial insects may be in order. Many beneficial insects can be purchased from commercial insectaries for release in fruit plantings. Examples of beneficial arthropods that have been used to control pests in fruit crops include the predatory mites *Phytoseiulus persimilis* and *Metaseiulus occidentalis*, which attack spider mites; lady beetles and green lacewings, which feed on aphids; and *Trichogramma* wasps, which parasitize the eggs of several pests, including codling moth.

As a rule, beneficial arthropods are not a complete control for direct fruit pests, at least not for commercial growers who have a low damage threshold for fresh fruit. Usually, additional control measures are necessary. There are four essential components for successful use of beneficial organisms for pest control.

1. *Selection of the proper natural enemy for a target*

pest. For example, *Trichogramma* wasps parasitize eggs and, therefore, do not directly control adult pests already active in the field.

2. *Proper timing of releases*. Release of natural enemies must coincide with a susceptible stage

of the host and should be made early enough in the cropping season to assure success.

3. *Correct rate of release for natural enemies*. This is usually based on the planting density.
4. *Environmental provisioning*. Make sure environmental needs – such as nectar sources, alternate prey, and water – are available for adult beneficial insects. If the necessary environment is not available, beneficials may leave the release area, die, or spend so much time searching for nectar or pollen that they do not efficiently attack pests.

Applying Materials: Pesticides Allowed in Organic Production

Allowed materials include only natural (non-synthetic) materials that are not specifically prohibited, and specifically allowed synthetic materials, as described in 7 CFR §205.600-602 of the NOP. Most, if not all, allowed synthetic materials have annotations that closely restrict how (in purpose, application method, and quantity) they can be used. Before you apply any product, make sure it's allowed for use in organic agriculture. Read the label carefully. Are all the active ingredients allowed? What about the inert ingredients? If it contains any undisclosed inert ingredients, you must have documentation from the manufacturer to confirm that all inerts are allowed by the National Organic Program (on EPA List 4). If in doubt, ask your certifier before you use it.

Many beneficial insects can be purchased from commercial insectaries for release in fruit plantings.

Information to guide your selection and use of materials

- NOP Standards: The National List 205.600-602. This is USDA's ultimate authority. This list, however, can be difficult to use because it is not a positive statement of materials that can and cannot be used. Instead, it states that all natural (non-synthetic) materials are allowed, unless they are prohibited (those materials on list 206.602), and that all synthetic materials are prohibited unless they are allowed, many with restrictions, as named and described on list 205.601. In some instances, it is not clear whether a material is natural or synthetic. For that reason, many organic producers and certifiers also use related resources to help interpret the National Lists and determine the allowability of substances in organic production.
- The Organic Materials Review Institute (OMRI) reviews and evaluates materials for consistency with the National List and publishes and maintains two other lists. The Brand Name List is available in hard copy and on the Web at www.omri.org. The Generic Materials List is available in hard copy to members for a small fee. These generic and brand-name lists provide an extremely useful resource to help growers identify allowable materials and products. While many organic producers, handlers, and certification agencies rely on and frequently refer to the OMRI lists, users should be aware that OMRI is an independent nonprofit organization, and USDA has not formally recognized or authorized OMRI to interpret the National Organic Standards.

Several new disease-control materials on the market are allowed for use in organic agriculture, including biofungicides, mineral-based essential oil extracts, and botanical fungicides. Growers in some regions are also using compost teas and plant extracts. The OMRI list provides information about the allowability of brand name products, but not their efficacy. You can ask your local Extension agent about any research or use in

your region. Copper and sulfur compounds are fungicides that are allowed (with restrictions on their use) and have been used historically by organic growers, but they have several drawbacks. These materials can damage plants if applied incorrectly. Sulfur dust can cause acute eye and respiratory irritation in humans. It is also lethal to some beneficial insects, spiders, and mites, and can set the stage for further pest problems. Long-term frequent use of copper fungicides can also lead to toxic levels of copper in the soil.(20)

Fertilization

Fruits, being largely water and sugars, remove relatively few nutrients from the soil, compared to other crops. Therefore, much of a fruit crop's fertility needs can be met through cover crop management and organic mulches (in systems that use them) and by the application of lime and other slow-release rock powders at the pre-plant stage. Supplementary fertilization may still be required for optimal growth and production.

There are many commercial organic fertilizers available. As noted above, however, organic growers should be familiar with organic standards, and especially the National List of Allowed Materials in the NOP's 7 CFR §205.600-602.

The NOP Rule requires that applied raw manure be incorporated at least 90 to 120 days before harvest of crops for human consumption (90 days if the edible portion does not have contact with soil or soil particles; 120 if it does). Compliance is easy: move grazing animals to another pen or paddock at the appropriate time.



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General fertilizer guidelines

- Organic fertilizers—especially uncomposted animal manures—should be incorporated into the soil to avoid nitrogen volatilization and to comply with organic standards. Use shallow tillage to prevent damage to plant roots and to minimize the potential for soil erosion. Manures should be incorporated into the soil at least three or four months before harvest (depending on the crop type) to comply with National Organic Program standards (7 CFR §205.203 (c) (1)).
- Soluble organic fertilizers such as fish emulsion, kelp, and soybean derivatives are suitable for use in drip irrigation and can provide quick supplemental fertility. Compost teas may be allowed and may contribute to disease control (see ATTRA's *Notes on Compost Teas*). Be sure to check with your certifying agency regarding current interpretations of the organic standards for compost production and any restrictions on the preparation or use of compost teas.
- Most organic fertilization programs focus on supplementing nitrogen as the key element, since it is needed in the greatest amount for the crop. You can calculate rates of organic amendments based on standard recommended rates for the crop, but be aware that many fertilizer recommendations still assume the use of synthetic materials. Organic systems behave differently. They generally use slower-release fertilizers and rely on biological activity to break them down into forms that can be absorbed by the plants. For example, only a portion (perhaps half) of the nitrogen applied as stable compost may be available to plants in the first year. The rest is stored and released gradually. To compensate for this, the producer may apply twice as much nitrogen as is needed in the first year of organic management. In subsequent years, however, more of the nitrogen is released from the soil organic matter and becomes available. In a mature organic farming system, nutrients and organic matter are added to maintain, replenish, and build the bank of nutrients in the soil.
- When making fertilizer calculations based on nitrogen, growers need to credit the estimated contributions made by legume cover crops and/or mulches. A cover crop of subterranean clover, properly fertilized and inoculated, can fix from 100 to 200 pounds of nitrogen per acre annually in a “living mulch” system.(8) Other legume cover crops may produce as much or even more, depending on things such as planting date, weather, and mowing.
- Consider the overall fertilizer analysis; basing application rates solely on nitrogen content can cause problems when the fertilizers are not balanced to meet the needs of the crop. For example, repeated use of poultry manure, which is very high in phosphate, can lead both to pollution problems and to zinc deficiency in the crop. These problems can be avoided by regularly monitoring and adjusting fertilizer selection and rates.
- The most reliable means for determining whether fertilization is adequate is to combine field observations with soil or tissue testing. Poor yields, unusual coloration of leaves, and poor plant growth are all clues to a possible nutritional imbalance or deficiency. On most fruit trees, slow elongation of branches often indicates a nitrogen deficiency. Yellowing between the veins of new blueberry leaves usually means the plant is suffering an iron deficiency. Corky bark on certain apple varieties can indicate an over-availability of manganese in the soil.
- Foliar analysis measures the nutrient content of the leaves and can identify a nutrient deficiency or excess well in advance of visible symptoms. It is more helpful than a soil test because the foliar analysis is a measure of what the plant is actually taking up, while a soil analysis only measures what is in the soil—which may or may not be available to the plant. Annual foliar analysis generally provides the best guide for adjusting supplementary nitrogen fertilization.

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Organic apple growers on California's Central Coast say that most years they plant only rye or other grass cover crops, because leguminous cover crops would contribute too much nitrogen, inducing excess growth, creating more pruning work, and decreasing fruit production. Growers monitor their nitrogen levels through leaf-tissue and soil analysis, and manage their soil covers accordingly.

For more detailed information regarding sustainable soil fertility management, including the use of organic fertilizers and nutrient testing methods, request these ATTRA publications: *Sustainable Soil Management*, *Alternative Soil Testing Laboratories*, *Alternative Soil Amendments*, *Foliar Fertilization*, and *Sources of Organic Fertilizers and Soil Amendments*.

Organic Weed Management

Some weed control methods, such as smother crops, are discussed in the **Site Preparation** section above. This type of cover cropping is an important tool for weed management that also contributes to good soil management, fertility, and pest management.

Mulches

Organic Mulch

Mulching is a powerful weed management strategy that can also contribute to good soil management, if appropriate natural materials are used. After a planting is established, weeds

can be suppressed by applying thick layers of mulch. This can also create habitats for beneficial arthropods, including generalist predators such as big-eyed bugs, soft-bodied flower beetles, and spiders. Organic mulches are usually applied in a circle around tree trunks or vines, and down the whole row in blueberries.

Commonly, tree fruit growers keep mulches away from the tree trunks, particularly in winter, to prevent voles or mice from gnawing on the bark and damaging

young trees. Keeping mulches 8 to 12 inches away from the trunk also reduces the likelihood of crown rot and other diseases in susceptible species – most notably apples on certain rootstocks.(23)

Mulch materials may include straw, spoiled hay, leaves, yard trimmings, woodchips, and sawdust. Many of these materials are inexpensive. Still, it's wise to weigh the benefits and risks of each, including hauling costs and the risks of their containing impurities and prohibited materials.

Municipal greenwaste may be available, either raw or from municipal or commercial composting operations. Growers must monitor the incoming product and remove any trash to keep undesirable material out of their fields. Growers should ask compost producers about the sources of their materials and any pesticides that may persist in them. Of particular concern are clopyralid and picloram, herbicides that are extremely resistant to breakdown, even after composting. The sale and use of these materials is restricted in some areas. A Washington State University study showed treated grass clippings to be the primary source of clopyralid entering the organic waste stream. Experience from California, Oregon, and Washington shows that at levels of 1 to 10 parts per billion, clopyralid adversely affects sensitive vegetable crops.(21, 22)

Because organic mulches decompose over time, they require periodic re-applications in order to continue suppressing weeds. However, their decomposition provides other benefits. Mulching with organic matter enhances soil aggregation and water-holding capacity.(4) Researchers from

1937 to the present have consistently found that mulching is the best orchard-floor management system for retaining moisture.(15) In Michigan research, mulching was as effective as irrigation in encouraging tree growth.(24) Organic mulches can have positive effects on tree growth, with improvements in soil quality and shifts toward beneficial nematodes.(27) Mulch can also benefit the crop by moderating soil temperatures, thus reducing plant stress.

Organic mulches provide slow-release nutrients for the long-term health and fertility of the soil. Research indicates that potassium, phosphorus, and nitrogen (primarily from the slow breakdown of the mulch) are more available in mulched systems than in non-mulched systems.(4) Some growers express concern that sawdust may acidify their soil or bind nitrogen in the soil. However, these effects are minimal if the sawdust is not tilled into the soil.

Raising organic matter on the farm is one way to ensure sufficient, clean mulching material. Farm-raised hay grown outside the orchard can provide weed-free mulch. Cover crops may be grown between tree rows, mowed, and gathered around the trees. Some small-scale growers use the biomass from orchard alleyways, cutting cover crops with a sickle-bar mower and hand-raking the material under the trees. Larger-scale operations often use forage wagons, straw-bale spreaders, or specialized equipment to mechanize mulching jobs. King Machine Co. (25) offers a small, trailer- or truck-mounted square-bale chopper and blower suitable for most fruit crops. Millcreek Manufacturing Co. (26) has developed a row mulcher especially suitable to blueberry, bramble, and grape culture, but also useful in tree fruit orchards. The Millcreek machines are designed to handle bulk organic materials such as sawdust, wood chips, bark, peat, and compost.

Geotextiles

Geotextile mulches are paper or woven plastic fabrics that suppress weed growth. While they allow some air and water penetration, they may reduce water infiltration, whereas organic mulches increase infiltration.(27) Geotextile mulches do

not provide the advantages of adding organic matter and nutrients to the soil, and if synthetic, they must eventually be removed. Geotextiles have a high initial cost, though this may be partially recouped in lower weed-control costs over the material's expected field-life—5 to 10 years for polyester fabric; 2 to 3 years for paper weed barriers. Still, some growers find them useful for weed suppression in orchards, tree plantations, and cane fruit culture. The ATTRA publication *Sustainable Pecan Production* provides more detail on the use of geotextiles and outlines additional methods of weed control, including mechanical cultivation, mulches, wood chips, and living mulches.

Sheet Mulch

You can also create weed barriers by sheet mulching: laying down layers of cardboard or newspaper and covering

them with organic material. Sheet mulching increases the efficacy of organic mulch as a barrier against emerging weeds. Organic growers should avoid cardboard that is waxed or impregnated with fungicide, as well as color print and glossy paper, in order to be compliant with the National Organic Program standards (7 CFR §205.601(b)(2)(i) and 205.601 (c)).

Cultivation

Cultivation—using mechanical tillage and weed harrowing implements—is the most widely used weed-management practice in fruit production. In systems that maintain permanent vegetation between rows, cultivation may be limited to the tree row under the dripline in an orchard, or extended 1 to 3 feet from the edge of the hedgerow in bramble plantings. The reverse is true where mulches are used in the tree row, and cultivation is used to control weeds and incorporate cover crops in the alleyways. In any case, cultivation must be kept shallow to minimize damage to crop roots and to avoid bringing weed seeds to the surface.

Hand cultivation—enhanced with the use of a wheel hoe—can be effective in small-scale plantings. In large-scale plantings of trees or vines, where in-row tillage is desired, “mechanical

hoes” such as the Weed Badger (28) or Green Hoe (29) are very useful. These tractor-mounted, PTO-driven cultivators can till right up to the tree or vine without damaging the plant. Attachment options include powered rotary tillage tools and scraper blades that can move soil either away from or toward the base of the crop plants. Scraper-blade attachments, commonly known as “grape hoes,” have been used in vineyards for decades.

Herbicides Allowed for Use in Organic Production

A few herbicides currently emerging on the market are allowable for organic production, with restrictions on the location of their use. There is ongoing research on using materials such as vinegar, corn gluten, and citric acid as herbicides, although they are not yet widely used by certified organic growers. Such materials may have applications in organic systems, such as for spot treatment of noxious weeds.



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Weeder Geese, Chickens, and Ducks

For many years, farmers have used geese to control weeds in perennial and annual crops, including strawberries, blueberries, bramble fruits,

and tree orchards. In Oklahoma, researchers at the Kerr Center for Sustainable Agriculture used weeder geese in commercial-scale blueberry and strawberry production, with portable electric fencing to keep the birds in a specific zone in the plant row.(30) Investigators at Michigan State University studied the impacts of populations of domestic geese and chickens in a nonchemical orchard system. They found that the geese fed heavily on weeds—especially grasses—and also on windfall fruit.(31) In general, geese are more effective against emerging or small grass weeds, and they have a particular preference for Bermuda grass and Johnson grass—weeds that can be especially troublesome in orchards.(32) ATTRA has additional information on weeder geese available on request.

Those who have raised chickens know how enthusiastically they devour fresh vegetation. If the area they inhabit is small, they will strip it to the dirt. Properly managed, however, their foraging characteristics can be used to the grower’s advantage.

Fred Reid is an innovative producer of raspberries and vegetables in Canada who has successfully employed his flocks of chickens in weed management. He uses a system of fencing to keep chickens in certain areas to accomplish a thorough job of weeding and insect control. He notes that if the vegetation has grown too high and the plants become too fibrous, the chickens will not eat them. However, if you mow tall vegetation in advance, the chickens will process it readily. He excludes the chickens from raspberry plots when the new, tender leaves are emerging and, of course, near harvest time.(33)

Flame Weeding

Flame cultivation uses directed heat to kill weeds. It works not by burning the weeds but by searing them and causing the plant cells to rupture. Farmers began using tractor-mounted flamers in orchard and row crops in the 1940s.(34) Technology and technique have both been refined considerably in recent years. Several tools now commercially available, including flame, infrared, and steam weeders, make heat a viable option for some weed management applications. See the ATTRA publication *Flame Weeding* for more information.

Management of Vertebrate Pests:

Mammals and Birds

Several bird species, deer, rabbits, ground squirrels, gophers, mice, voles, raccoons, and other animals can be serious pests of fruit plantings. Organic certification calls for an integrated approach to vertebrate management, including exclusion, trapping, repellents, scare devices, and protection or development of predator habitat.

Gophers and ground squirrels can be managed on organic farms through integrated strategies. Thomas Wittman of Gophers Limited emphasizes that growers should not expect to eliminate these pests, but will do well to keep populations in check. He stresses the importance of keen observation and has tips for effective trapping routines using commercially available traps. Persistent year-round trapping is the primary strategy for most farmers, complemented by enhancing the habitat of key predators such as owls and hawks with nestboxes, perches, and appropriate vegetation.(35)

Explosive propane devices are effective against gophers and ground squirrels. Pro-

pane gas ignited in rodent burrows creates an explosion that kills the animals and disrupts their tunnels. Several organic orchardists say that this works, but most promptly abandoned its use because neighbors complained about the noise of the explosion, similar to the sound of a gun shot. Only two materials (sulfur dioxide for underground smoke bombs and Vitamin D3, or Cholecalciferol) are on the National List as rodenticides. These may be used only if they are documented in the Organic System Plan, used with care to avoid harming non-target animals, and only when other management practices are ineffective.

Birds can be especially troublesome in cherry, berry, and grape plantings. Exclusion with bird netting is probably the surest control, but the initial cost can be high for both the material and its placement. Noise devices, “scare-eye” balloons, Mylar tape, artificial hawk kites, and many other home remedies have been tried, with varied success. Successful scare tactics depend on the bird species, bird population pressure, and the grower’s management of the devices. It is important to remember that birds and other vertebrate pests

are quick to learn, and they often overcome their initial aversion to scare devices or repellents. The grower will achieve the most effective control by moving devices frequently, and by changing or mixing the devices. For example, organic growers describe how they effectively scare certain bird species away from newly emerging crops by placing red- and silver-colored Mylar tape in the field for just a few weeks, then removing it so that the birds do not get used to seeing it. Fruit growers use sonic and visual scare devices only at critical times in the growing season, such as fruit ripening, and remove them promptly as soon as that period is over.

Deer can be devastating to fruit plants, especially young orchards. Methods for preventing or controlling deer damage to crops range from exclusion and cultural methods to scare devices, repellents, and culling or harvest. For more information, see the ATTRA publication *Deer Control Options*. Scent and taste repellents may be effective under light deer pressure, especially if the

Birds can be especially troublesome in cherry, berry, and grape plantings.

grower switches periodically from one repellent or deterrent to another. Re-

search at the University of Wisconsin (36) indicates that none of these repellents is very useful under heavy deer pressure. Exclusion fencing may be the only way to manage heavy deer populations. In most states, the Cooperative Extension Service provides suitable plans for deer fencing. Electric fencing appears most effective. Research indicates that even a single strand of electrified wire can work. Where deer problems are severe, however, a seven-strand, sloped, electrified fence may be necessary.(37)

Tree guards made of plastic, hardware cloth, or similar materials can keep rabbits from gnawing on fruit tree trunks.(38) However, northern growers should remember that snow can effectively raise the gnawing height of rabbits.

Mice and voles may be attracted to mulch around fruit plants. Such rodents take up residence in mulch during the winter, feeding and gnawing on roots, stems, and trunks. To reduce the chance of vole damage, mulch should be raked away from the plants in the fall (usually 18 to 24 inches is adequate). Mulch removal may not be practical, however, for blueberry plantings. Keeping the

planting site mowed also helps reduce rodents by exposing them to natural predators such as hawks and owls. For pests such as raccoons, opossums, skunks, etc., tight web-type fencing or non-lethal traps are the best control options.

POSTHARVEST HANDLING

Many fruits require some type of postharvest handling. Whether done on-farm or off, these processes must be documented in the Organic System Plan. Any off-farm postharvest handling must be done by certified organic facilities, and appropriate measures must be taken to prevent commingling or contamination of organic products with non-organic products during washing, sizing, packing, and storage. A complete audit trail must track produce from its field of origin to the point of final sale. Growers should read the National Organic Program Final Rule, review the National List, OMRI lists, and consult with their certifiers about any materials to be used postharvest, such as cleansers, shellacs, or waxes.

CONCLUSION

Organic fruit production is a practical option for some growers, but the viability of the enterprise will likely hinge on site, scale, type of fruit, markets, and managerial skills. In general, crops grown in the drier climates of the West have fewer disease and pest problems. This region may, therefore, be better suited to organic fruit production. Strawberries, bush fruits, and brambles are probably easier to grow organically in most sections of the country than grapes and tree fruits. Management requirements for organic production are likely to be higher in any region, and the producer must be closely attuned to local site conditions.

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P.O. Box 586
Scottsburg, IN 47170
812-752-6000
800-365-2467 (toll-free)
www.kingmachine.com
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2617 Stumptown Road
Leola, PA 17540
800-311-1323 (toll-free)
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5673 SE 95 Avenue
Marion, ND 58466-9718
800-437-3392 (toll-free)
www.weedbadger.com
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6645 West Main Road
Portland, NY 14769
716-792-9433
716-792-9434 FAX
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RESOURCES

Sources of Supplies

Harmony Farm Supply
P.O. Box 460
Graton, CA 95444
707-823-9125
707-823-1734 FAX
www.harmonyfarm.com

Flame Engineering, Inc.
P.O. Box 577
LaCrosse, KS 67548-0577
913-222-2873
800-255-2469 (toll-free)
www.flameengineering.com/

Thermal Weed Control Systems, Inc.
N1940 Hwy. 95
Neillsville, WI 54456
715-743-4163

Periodicals

American Fruit Grower
Meister Publishing Company
37733 Euclid Ave.
Willoughby, OH 44094
440-942-2000
www.meisternet.com

Monthly. \$19.95/yr.

Good Fruit Grower
105 S. 18th Street, Suite 217
Yakima, WA 98902
509-575-2315
509-454-4186 FAX
www.goodfruit.com
growing@goodfruit.com

\$30/yr.

Fruit Growers News (formerly Great Lakes Fruit Growers News)
P.O.Box 128
Sparta, MI 49345
616-887-9008
616-887-2666 FAX
gap@i2k.net

Monthly. \$11/yr.

Pomona
North American Fruit Explorers
1716 Apples Rd.
Chapin, IL 62628

Quarterly. \$10/yr.

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Flint, Mary Louise. 1990. Pests of the Garden and Small Farm. Division of Agriculture and Natural Resources Publication 3332. University of California, Oakland, CA. 276 p.

Primarily for California, but lots of good information for any fruit grower.

From: ANR Publications
University of California
6701 San Pablo Ave
Oakland, CA 94608-1239
510-642-2431

800-994-8849 (toll-free)

www.anrcatalog.ucdavis.edu.

Galletta, Gene, and David Himelrick, (eds.). 1990. Small Fruit Crop Management. Prentice Hall, Englewood Cliffs, NJ. 602 p.

Out of print. Check with any library's interlibrary loan program to borrow a copy. Includes chapters on minor fruits such as elderberries, juneberries, kiwifruit, etc.

Pfeiffer, Ehrenfried. No date. The Biodynamic Treatment of Fruit Trees, Berries, and Shrubs. The Biodynamic Farming and Gardening Assoc., Inc., Kimberton, PA. 30 p.
Available from:

The Biodynamic Farming & Gardening Association

P.O. Box 29135

San Francisco, CA 94129-0135

415-561-7797

biodynamic@aol.com

www.biodynamics.com

Reich, Lee. 1991. Uncommon Fruits Worthy of Attention. Addison-Wesley, Reading, MA. 273 p.

Though not expressly for commercial growers, it provides otherwise hard-to-find information on minor fruit crops like pawpaws, jujubes, mulberries, etc.

Ryugo, Kay. 1988. Fruit Culture: Its Science and Art. John Wiley & Sons, New York, NY. 344 p.

Whealy, Kent. Fruit, Berry and Nut Inventory. Seed Saver Pubs., Decorah, IA. 366 p.
Descriptions of various fruit cultivars extant in U.S. nursery trade.

Seed Savers Exchange

3076 N. Winn Road

Decorah, IA 52101

319-382-5990

sse@salamander.com

Web Resources

Listings of Educational Institution and Government Sponsored Sites

www.crfg.org/related.edu.gov.html

U.C. Fruit and Nut Research and Information Center:

<http://fruitsandnuts.ucdavis.edu/>

This site has links to specific crops, lists of farm advisors, current research and many

other useful resources.

UC Davis Postharvest Technology and Information Center

<http://postharvest.ucdavis.edu/Produce/Storage/index.html>

This site provides practical information on postharvest handling of many products.

University of Missouri Extension Publications

<http://muextension.missouri.edu/xplor/agguides/hort/#Fruit>

While this site includes information for home orchards, there is a piece entitled “Information Sources for Planning a Commercial Fruit Operation” that includes contact information for local Extension horticulture specialists:

<http://muextension.missouri.edu/xplor/agguides/hort/g06011.htm>

California Rare Fruit Growers

www.crfg.org/

This organization covers a fascinating plethora of tropical fruits, but does not have a commercial emphasis. Contains abundant information on deciduous fruits as well.

Cornell Cooperative Extension Fruit Production Resources

www.hort.cornell.edu/extension/commercial/fruit/treefruit.htm

Much of the pest management information on this site appears to be pesticide-focused at first glance. However, one article discusses Organic Treefruit and IPM:
www.nysaes.cornell.edu/ent/treefruit/2002_treefruitPdf/IntCropAndPM.pdf

There are links on this site to “Other State Resources,” such as the following two examples.

University of Connecticut IPM for Tree Fruit

Crops

www.canr.uconn.edu/ces/ipm/ipmtrfr.htm

Western Maryland Research & Education Center

www.canr.uconn.edu/ces/ipm/ipmtrfr.htm

There are many other state programs that have information on fruit growing, which may or may not have significant resources for organic orchard production.

Kearneysville Tree Fruit Research and Education Center, West Virginia University

www.caf.wvu.edu/kearneysville

This site features keys to pest identification, with great photos of insects and disease symptoms. Lots of useful information for fruit growers in the Mid-Atlantic region. On-line newsletters and publications are archived. Links to other sites.

The Mid-Atlantic Regional Fruit Loop

www.caf.wvu.edu/kearneysville/fruitloop.html

A cooperative effort bringing together information on deciduous fruit tree production in the Mid-Atlantic region. Cooperating state universities include Virginia Tech, West Virginia University, the University of Maryland, Penn State University, and Rutgers University.

North American Fruit Explorers

www.nafex.org/

*Members of this network are professional and amateur fruit growers who share information here and in their quarterly journal, Pomona (see **Periodicals** section).*

UC Davis Pomology Dept:

<http://fruitsandnuts.ucdavis.edu>

Links to all sorts of fruit information from University of California.

University of Massachusetts Tree Fruit

Advisor:

www.umass.edu/fruitadvisor/

Fact Sheet series addresses specific issues and crops. Information focuses on apples, but includes peaches, pears, plums, and cherries.

Horticulture Solutions Series. Illinois Cooperative Extension:

www.ag.uiuc.edu/~robsond/solutions/horticulture/fruits.html

USDA articles and updates on organic farming.

www.ers.usda.gov/briefing/Organic/readings.htm

This site features tidbits of information on specific issues: Economic Research Service briefing room, organic farming and marketing, recommended readings.

By Guy K. Ames and George Kuepper

Revised January 2004

By Ann Baier

Reviewed by Martin Guerena

NCAT Agriculture Specialists

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Edited by Paul Williams

Formatted by Ashley Rieske

The electronic versions of *Tree Fruits: Organic Production Overview* can be located at:

HTML

<http://attra.ncat.org/attra-pub/fruitover.html>

PDF

<http://attra.ncat.org/attra-pub/PDF/fruitover.pdf>

IP28/ Slot 33

Version 092104

PRUNING FRUIT TREES

**Publication
Number
31-S80**
(published Jan. 2002)

*AUTHOR: Chuck Ingels, Farm Advisor, Sacramento County University of California Cooperative Extension.
Edited by University of California Cooperative Extension Landscape Horticulturist Pamela S. Bone*

REASONS FOR PRUNING

YOUNG TREES

- To produce a strong framework to support the future crop
- To shape the tree
 - Establish proper training system
 - Set height of first branches
 - Provide for ladder access
- To produce fruit

BEARING TREES

- To improve sunlight penetration
- To remove unproductive fruiting wood and stimulate growth of new fruiting wood
- To control tree size
- To remove broken, dead, and diseased wood
- To remove crossing and crowded branches
- To control alternative bearing

RESPONSES TO PRUNING

- Usually reduces tree size
- Invigorates tree (vegetative growth)
- Usually increases fruit size
- Heading cut:
 - Removal of part of branch or shoot
 - Used to promote branch development, especially on young trees
 - Stimulates growth below cuts
 - Can reduce sunlight penetration
- Thinning cut:
 - Removal of entire branch or shoot

- Used to prevent crowding of branches
- Defines main branches
- Improves sunlight penetration

SUMMER PRUNING

YOUNG TREES

- Used for training scaffold branches
- Technique:
 - Pinch back unwanted shoots to 4-6 in
 - Pinch 2-3 ft long scaffold branches to promote side branching
- Reduces training time and shortens time to first fruit production

BEARING TREES

- Used for increasing sunlight penetration to improve productivity of lower fruiting wood
- Technique:
 - Remove some vigorous, upright shoots shading lower wood
- Can reduce tree vigor
- Can sunburn branches if excessive

PRUNING NEGLECTED TREES

- Goals
 - Reduce tree size
 - Increase sunlight to lower wood
 - Reduce height of fruiting wood
 - Prune sagging branches to laterals
- Retrain over 2-3 year period
- Paint exposed large limbs with white interior latex paint (diluted 50:50 with water)

Originally appeared as *Environmental Horticultural Notes #80*. 1997. University of California Cooperative Extension Sacramento County .



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Placer County

WEB SITE: ceplacervevada.ucdavis.edu

Nevada County



11477 E Avenue (Bldg 306, DeWitt Center)

Auburn, California 95603

(530) 889-7385

FAX (530) 889-7397

E-Mail: ceplacer@ucdavis.edu

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255 So Auburn (Veterans Memorial Bldg)

Grass Valley, California 95945

(530) 273-4563

FAX (530) 273-4769

E-Mail: cenevada@ucdavis.edu

FRUITING WOOD CHARACTERISTICS AND PRUNING OF FRUIT TREES

SPECIES	LOCATION OF FRUITING BUDS				SPUR LIFE (YEARS)	TYPE OF TRAINING SYSTEM	AMOUNT OF PRUNING FOR MATURE TREES
	ON LONG SHOOTS		ON SHORT SHOOT OR SPURS				
	LATERALLY	TERMINALLY	LATERALLY	TERMINALLY			
Almond	Minor		Major		5	Open Center	Light (thinning)
Apple	Minor	Very Minor		Major	8-10+	Central Leader or	Medium
Apricot	Minor		Major		3		Heavy
Asian Pear	Minor	Very Minor		Major	6-8	Open Center or Central Leader	Medium to Heavy
Cherry, Sour	Major or		Major or			Open Center	Light
Fig	Minor	Major			Bear on 1-yr & New Shoots	Open Center or Modified C.L.	Various
Nectarine	Major		Minor		1-2	Open Center	Heavy
Peach	Major		Minor		1-2	Open Center	Heavy
Pear	Minor	Very Minor		Major	8-10	Central Leader of	Medium
Persimmon	Major	Minor			Bear on New	Modified Central	Light (mainly
Plum,	Very Minor		Major		6-8+	Open Center	Medium
Plum,	Minor		Major		6-8	Open Center	Heavy (mainly
Quince	Major	Minor			Bear on New	Open Center or	Light (mainly
Walnut	Minor on	Major on	Minor on	Major on		Modified Central	Light (thinning)





FERTILIZING CITRUS IN THE FOOTHILLS

Publication
Number
31-011C
(published January
2004)

AUTHOR: Cindy Fake, Horticulture and Small Farms Advisor, Nevada & Placer Counties

Citrus trees are not very nutrient demanding, but production of a high quality crop requires adequate amounts of the essential nutrients. Most growers need to add nitrogen and zinc on an annual basis. Manganese deficiencies are fairly common, and in the foothills, boron and iron may also be deficient. Potassium is important in fruit development and may need to be supplemented. In acid foothill soils, phosphorus is often unavailable and may need to be added.



The best tool growers have for determining tree nutrient status is leaf tissue analysis. By providing an accurate assessment of plant, rather than soil, nutrient status, deficiencies can be identified and corrected. Analysis may indicate high or low nutrient levels that may not be optimal, but are not yet manifesting symptoms. Starting in the fourth year, samples should be taken every other year and analyzed for nitrogen, phosphorus, potassium, zinc, manganese, and boron.

Macronutrients

Nitrogen (N)

Citrus grown in the foothills generally needs supplemental nitrogen. Nitrogen deficiency

manifests as an overall yellowing of foliage, beginning with the older leaves and progressing to younger growth. Poor flowering, which affects yields, and stunted growth are also symptomatic of insufficient nitrogen. In cases of severe deficiency, leaves drop and foliage becomes sparse. N deficiencies often occur in winter or early spring because of low N reserves in the tree, low soil temperatures which reduce N mineralization rates, and lack of root activity due to low temperatures and saturated soils.

Nitrogen may be applied to the soil in granular form, through the irrigation system, or sprayed on the foliage. Nitrogen fertilizers are usually split into three or more applications, starting in late February or early March. Winter nitrogen applications are not very effective as much of the N will be lost to run-off or leaching, contributing to nitrate pollution of waterways. Pre- and post-bloom (after petal fall) foliar N applications are an effective alternative to soil application. Research has shown that foliar applications of low biuret urea, up to a quarter of the N requirement, can significantly increase fruit set and yield in oranges (Lovatt). Spring applications are critical as the highest demand for nitrogen is from bloom through June.

Adequate nitrogen is important during this period for development of growth flushes, flowering, and fruit set.

N fertilizer applications should be completed by mid-August to avoid stimulation of late growth flushes that are susceptible to cold damage or impacts on fruit quality. High N levels in late summer and fall may also contribute to poor fruit color, thicker rinds, and less juicy fruit. Excessive amounts of nitrogen will reduce fruit size and quality, and may delay maturity.

Young citrus trees require nitrogen for good growth and development. Two to four ounces of actual nitrogen per tree are required the first year, ¼- ½ lb. the second year, and ½ to ¾ lb. the third year. Young trees do not have well developed root systems, so either a slow release form should be used or the nitrogen should be split into 5 or 6 applications from late February through August. From the fourth year on, citrus are treated as mature trees, requiring 1 to 1½ pounds of actual nitrogen per tree per year. Use the lower recommendations for trees on rootstocks with trifoliolate parentage (e.g. Rich 16-6, Rubidoux, C-35).



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To calculate nitrogen needs, use the nutrient analysis on the fertilizer bag and the recommended amount for the age of the tree or recommendations from your leaf analysis. For example, you have a grove of new trees, each of which requires 3 ounces of actual N. Using a 15-15-15 fertilizer, which has 15% by weight of Nitrogen, Phosphorus, and Potassium, you will need to apply 20 ounces of the fertilizer to each tree to obtain 3 oz. actual N. ($3 \text{ oz.} \div 0.15 [15\% \text{ N}] = 20 \text{ oz.}$ [$1\frac{1}{4} \text{ lb.}$] of 15-15-15 fertilizer to supply 3 oz. N).

Phosphorus (P)

In some foothill soils, phosphorus may be fixed in insoluble compounds and not available to plants. Thus, citrus may need regular applications of phosphorus for optimal yield and quality. Deficiency symptoms appear first on older leaves as P is moved out of older tissues to where it is needed in younger tissues. Older leaves lose their deep green color and luster and may become slightly variegated, bronzed, or purplish. Leaves drop prematurely. Flower and fruit set are diminished and yields decline. Fruit on trees deficient in P have thick, coarse rinds, lower juice content, and maturity is delayed. Roots may be stunted.

Application of a water-soluble P fertilizer to the soil will correct deficiencies. Research has shown that a pre-bloom foliar application of phosphite (Nutri-phite 0-28-26) increases yield and an application in early summer increases fruit size and total soluble solids (Lovatt).

Potassium (K)

Moderate potassium deficiencies may occur in the foothills, but often there are no visual symptoms. A mild to moderate deficiency affects the rate of photosynthesis, reducing growth, and may result in poor fruit quality and decreased yields. Severe deficiencies may be recognized by yellow to yellow-bronze patterning on older leaves behind the fruit, and tip burning as the deficiency intensifies. Old leaves persist on the tree. Fruit are often smaller, with smooth, thin peel and may be more subject to splitting. Wood may fail to harden off, remaining green and subject to frost injury. Excessive nitrogen applications or insufficient soil moisture may induce potassium deficiencies.

To correct a K deficiency, make a foliar application of 30 pounds of potassium nitrate in 100 gallons of water. Apply when leaves of the first spring growth flush are expanding (usually April). One spray will suffice for a mild deficiency, but several applications may be necessary in more severe cases. Potassium nitrate applied through the drip system is also very effective. Soil application of 10 pounds of potassium sulfate, banded at the drip line of each tree, will also correct a K deficiency and lasts several years.

Micronutrients

Zinc (Zn)

Zinc deficiency is very common and can be very damaging to citrus production. It is often called "little leaf" or "mottle leaf" because of the reduced leaf size

and the distinctive leaf pattern. New leaves are mottled, pale yellow, and smaller than normal. Symptoms may be more noticeable on the south side of the tree and near the top. In mild cases, interveinal areas are yellow or cream colored, but veins remain green. As the deficiency worsens, mottling becomes more pronounced and veins begin to yellow. In severe deficiency, leaf tips and margins brown and die. Twigs die back and trees appear bushy and stunted.

Zinc deficiency may be brought on or exacerbated by excess phosphorus or nitrogen. Insufficient zinc affects tree vigor, resulting in reduced production, smaller fruit size, and lower fruit quality. If there is insufficient zinc in the soil, zinc will not be translocated to new growth flushes. It is usually necessary to make a foliar application of one pound of zinc sulfate (ZnSO_4) in 100 gallons of water to each new growth flush. Apply when new growth is almost fully expanded, but not yet hardened off.

Manganese (Mn)

Manganese deficiency is quite common in California citrus. In cold winter areas, temporary deficiencies may appear in late winter due to low soil temperatures and reduced root activity. Symptoms may disappear as temperatures rise and roots become active, but persistent symptoms should be treated. Yields are generally diminished if leaf symptoms persist for more than five months.

Mn deficiency symptoms are visible on new leaves as a

yellowing between the veins (interveinal chlorosis). Leaves are normal size, but the midrib and veins are blotchy or mottled green. The spring growth flush may exhibit more obvious symptoms, often more visible on the north side of the tree. As the severity of the deficiency increases, interveinal areas become lighter in color, almost white, and leaves drop prematurely.

Mild Mn deficiency reduces tree vigor and yield slightly. Severe deficiency will cause defoliation and significantly reduced vigor and yields. Mn deficiency frequently occurs in combination with zinc or iron, which may mask its symptoms. Leaf tissue analysis should be used to determine which nutrients are deficient.

Manganese deficiency can be corrected with a foliar spray of 1 pound of manganese sulfate ($MnSO_4$) in 100 gallons of water, at a rate of 800 gallons per acre. $7\frac{1}{2}$ pounds of low-biuret urea may be added to the mixture to facilitate Mn uptake. Zinc and manganese deficiency often occur at the same time, and 1 pound of zinc sulfate may be added to the spray to correct both problems. For the most effective application, apply in the spring when new growth is between half and two-thirds expanded.

Boron (B)

Some foothill areas, particularly those that have been graded, are subject to boron deficiencies, but others have excess B. Deficiency symptoms include bronzing of the leaves and death of terminal growing points, causing rosettes of multiple buds. Leaves become

thickened, curl downward, and upper leaf veins may enlarge and split. Premature leaf drop begins at the top of the tree, leading to defoliation. Growth is severely affected, especially in young trees.

Boron is included in some blended fertilizers with micronutrients, and regular application of this type of fertilizer is usually sufficient.

However, in cases of deficiency on young trees, apply 1 to 2 ounces of borax around the base of each tree in the spring. Boric acid may be applied as a foliar spray after bloom. Manures and composts contain trace amounts of boron, and these may also be applied.

If you suspect a deficiency, do not apply boron until you have results from the leaf analysis. The range between deficiency and excess is very narrow, and excess B can be very damaging to trees.

Iron (Fe)

Although red foothill soils may contain a lot of iron, it may not be available to plants, so iron deficiencies do occur, especially where drainage is poor. In addition, trifoliolate rootstocks, which include the recommended mandarin rootstocks Rich 16-6 and Rubidoux, as well as the commonly planted C-35, are less able to take up iron than other rootstocks.

Iron deficiency is commonly called iron chlorosis because the symptoms are light yellow to whitish colored young leaves with green veins. Sometimes, just one branch of a tree may be affected. When the deficiency is severe, the leaves may be small, thin, and fragile and fall off prematurely. Fruit are also small and pale

colored. Dieback occurs at the top and on the outside of the tree.

Iron deficiency is not easy to correct. Foliar application of iron is not effective. Soil application of iron chelates is more effective than foliar application, but not consistently. Changing irrigation practices or improving drainage may correct deficiency problems.

Leaf Analysis



Citrus leaf analysis should be done when nutrient levels in leaf tissues are stable, usually from mid-August through mid-October. University of California researchers have established critical ranges for specific nutrients in that period. Such analysis may indicate specific deficiencies or problems that are just beginning to develop. These can be used to modify your fertilizer program.

To sample leaf tissue, collect leaves from the spring growth flush (4 to 7 months-old) from non-fruiting branches. Each set of samples should represent a block of a single variety and rootstock and be similar aged trees growing in similar conditions. Walk diagonally through the orchard block, randomly picking leaves, one leaf from each sample tree. Pick average-sized, undamaged leaves from normal, healthy trees. Be sure that the sample includes leaves picked from each side (N-S-E-W) of the trees. Generally, each sample should include a minimum of 50 leaves, but check with your lab for specific instructions.

If one area of the orchard is weaker than others, sample it separately and compare the

results to those from healthier areas. Follow the same sampling procedure, choose normal-looking or slightly affected leaves, do not pick the worst affected leaves. Severely affected leaves may not give a true picture of nutrient status as the tree may have moved most nutrients out of them.

Place the leaves in a paper bag, and hold in a cooler or refrigerator until they are sent to the lab. The samples should be sent to the lab as soon as possible so that the results are accurate. It is best to use a lab that washes the leaves as part of the analysis.

The first time you do a leaf analysis, sample all of the elements. Once you have a baseline, check only the elements where a problem is suspected. The most common deficiencies in the foothills are nitrogen, zinc, and manganese. Boron, potassium, and phosphorus are sometimes deficient. Leaf analysis is a

helpful guide in orchard nutrition, but monitoring is critical. Careful observation is needed to detect changes in tree appearance, growth rate or fruit production. Be

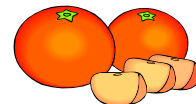
sure that a nutrient deficiency is really the problem before applying a fertilizer.

Critical Nutrient Levels for Citrus (oranges):

	Deficient Below	Optimum	Excess
Nitrogen (N)	2.2% >2.8%	2.4 - 2.6%	
Phosphorus (P)	0.09%	0.12 - 0.16%	>0.30%
Potassium (K)	0.40%	0.70 - 1.09%	>2.30%
Zinc (Zn)	16 ppm	25 -100 ppm	>300 ppm
Manganese (Mn)	16 ppm	25 - 200 ppm	>1000
Boron (B)	21 ppm	31-100 ppm	>260 ppm

n.b. mandarins may have slightly different levels, but should be close to this range.

From *Soil and Plant-Tissue Testing in California*.



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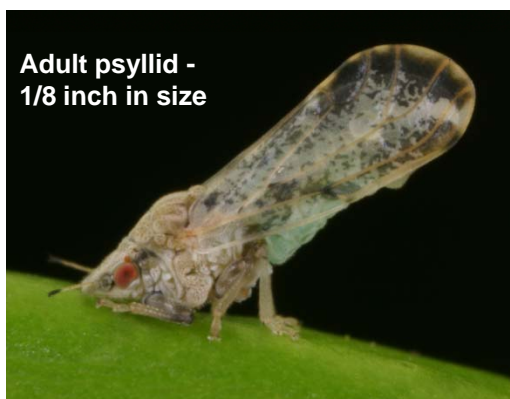
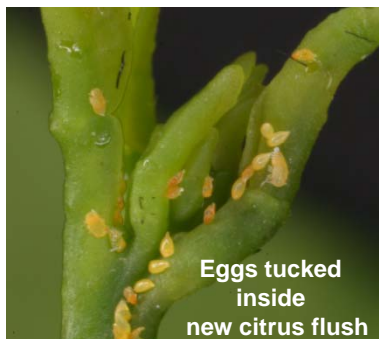
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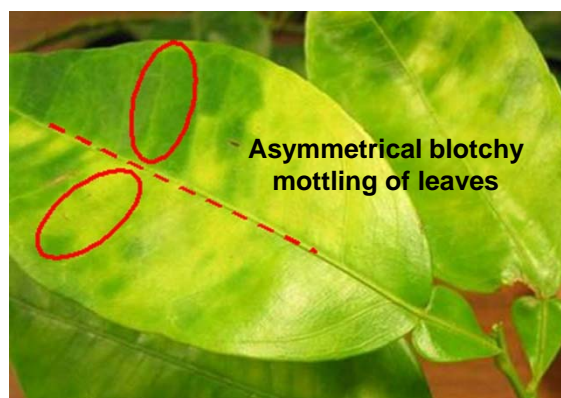
HAVE YOU SEEN THIS INSECT?

Asian Citrus Psyllid



The Asian citrus psyllid, *Diaphorina citri*, is a small, aphid-like insect. It feeds on the new flush of citrus and very closely related plants such as orange jasmine (*Murraya paniculata*). Psyllid feeding causes burned tips and twisting of the new leaves. More importantly, it can spread the bacterium that causes Huanglongbing (HLB) disease.

HAVE YOU SEEN THIS CITRUS DISEASE? Huanglongbing or Citrus Greening Disease



Huanglongbing (HLB), also known as citrus greening disease or yellow shoot disease, is a very destructive bacterial disease of citrus and closely related plants. It is spread primarily by psyllid insect vectors and through grafting with infected budwood. Symptoms include yellow shoots, leaf mottle, small upright leaves, and lopsided fruits with a bitter flavor. Diseased trees are non-productive and must be removed and destroyed to prevent further spread of the disease.

HLB is a serious threat to the California citrus industry.

**IF YOU SUSPECT YOU HAVE SEEN THIS INSECT
OR DISEASE CALL THE CALIFORNIA DEPARTMENT OF FOOD AND
AGRICULTURE HOTLINE: 1-800-491-1899**

*E. Grafton-Cardwell and G. Vidalakis, University of California Riverside
University of California ANR Core Grants Program
Photos by M. Rogers and M. Keremane*

REDUCED CHEMICAL PEST MANAGEMENT FOR FRUIT & NUT TREES

Publication
Number
31-S81

(Published
October 2001)

AUTHOR: *Chuck Ingels, UC Cooperative Extension, Sacramento County. EDITED by Christine Joshel, Center for Pest Management Research & Extension and Mary Lou Flint, IPM Education & Publications, UC Davis.*

As result of increasing environmental contamination and pesticide safety concerns, we strongly recommend the use of reduced or non-chemical approaches to pest management where possible. Integrated pest management (IPM) emphasizes the use of non-chemical methods first, and the use of chemical pesticides only as a last resort. These methods include proper pest identification, periodic monitoring, appropriate cultural practices, release of beneficial insects if appropriate, applications of lowest toxicity pesticides, and then application of certain pesticides if all other methods fail.

Be sure to thoroughly read all labels to determine if a pesticide is appropriate for a given pest and crop, and always use the protective clothing and gear stated on the label when applying pesticides. If your pest problem is eliminated with a single spray, or in the case of some fungicides if the weather turns dry, no additional sprays may be necessary, even though the label says to use every 7 to 14 days. When spraying, be sure to thoroughly cover leaves and/or branches.

In a few cases, beneficial insects may be purchased through mail-

order catalogs and released on the trees. Such insects include *Trichogramma platneri* for codling moth and *Aphytis melinus* for California red scale. Releasing lady beetles (lady bugs) is usually not effective because they quickly fly away. In most cases, predatory insects will come when the conditions are right.

Tables. The tables on the following pages are intended as a quick guide for managing pests using the least toxic approaches.

Products or methods in bold are preferred over others based on efficacy or safety. Some of the products and methods listed may not be as effective as chemical pesticides. For example, codling moth can be very difficult to control using cultural practices. Oil and other low-toxicity insecticides are not effective or require a large number of applications if populations are high. In some cases, applications of Sevin may be the only effective control measure for codling moth.

For more thorough information, several publications are available from your local UC Cooperative Extension office. Some of the information in these publications is more suited for commercial producers rather than backyard gardeners.



- *Pests of the Small Farm and Garden*
- *Pests of Landscape Trees and Shrubs*
- UC IPM *Pest Notes* (free; also on web site - see below): Aphids, Codling Moth, Cottony Cushion Scale, Fire Blight, Leaf Curl, Powdery Mildew, Scales, Spider Mites, Thrips, and Walnut Husk Fly.
- *Integrated Pest Management publications* for: 1) Stone Fruits, 2) Apples and Pears, 3) Citrus, 4) Almonds, and 5) Walnuts.

In addition, the most up-to-date information can be found on the UC IPM web site: <http://www.ipm.ucdavis.edu>.

Adapted from *Environmental Horticultural Notes* #81. January 2000. UC Cooperative Extension, Sacramento County.



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WEB SITE: ceplacervevada.ucdavis.edu

Nevada County



11477 E Avenue (Bldg 306, DeWitt Center)
Auburn, California 95603
PHONE (530) 889-7385
FAX (530) 889-7397
E-Mail: ceplacer@ucdavis.edu

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United States Department of Agriculture, University of California, Placer & Nevada Counties cooperating.

255 So Auburn (Veterans Memorial Bldg)
Grass Valley, California 95945
PHONE (530) 273-4563
FAX (530) 273-4769
E-Mail: cenevada@ucdavis.edu

SUMMARY OF REDUCED CHEMICAL METHODS OF MANAGING SELECTED
INSECT AND DISEASE PESTS OF BACKYARD FRUIT TREES

-- DORMANT SEASON--

Disease or Insect	Product or Method	Signal	When to Use	Frequency	Comments
<i>Peach leaf curl</i> (peach, nectarine)	Copper product (e.g., copper sulfate, fixed copper)	WARNING	1)Late fall and 2)At bud swell	1-2x /year	Toxic to some soil or- ganisms. Product must contain at least 50% copper.
<i>Shot hole</i> (almond, apricot, peach, nectarine)	Lime sulfur	DANGER	1) Late fall and 2) At bud swell	1-2x /year	May cause eye dam- age. Do not use on apricot. Not registered for use on almond.

NOTE: Copper or lime sulfur should be applied to peaches & nectarines each year; fall spray may be adequate except in wet springs. Copper is preferred because it is less hazardous. Do not mix lime sulfur with oil. Use spreader sticker to reduce washing off by rain.

<i>European fruit lecanium (scale)</i> (decid. fruits/nuts)	Superior/ Supreme Oil	CAUTION	Early dormant season (by mid-Jan.)	1x per year	Avoid use of products labeled "Dormant oil", it may injure trees. Do not use within 30 days of sulfur or cap- tan Can also treat scale with summer oil during crawler stage, but timing is more diffi- cult. Avoid applying oil during dry, warm, and windy periods; best to apply just <i>after</i> rain or fog.
<i>Red mites, aphid eggs, San Jose scale, kuno scale, walnut scale</i> (decid. fruits/nuts)	Superior/ Supreme Oil	CAUTION	Late dormant season to bud swell	1x per year	

WARNING ON THE USE OF CHEMICALS : Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in the original labeled containers in a locked cabinet or shed, away from food or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.

Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits and/or vegetables ready to be picked.

Dispose of empty containers carefully. Follow label instructions for disposal. Never reuse containers. Make sure empty containers are not accessible to children or animals. Never dispose of containers where they may contaminate water supplies or natural waterways. Do not pour down sink or toilet. Consult your county agricultural commissioner for correct ways of disposing of excess pesticides. Never burn pesticide containers.

PHYTOTOXICITY WARNING: Certain chemicals may cause plant injury if used at the wrong stage of plant development or when temperatures are too high. Injury may also result from excessive amounts of the wrong formulation or from mixing incompatible materials. Inert ingredients, such as wetters, spreaders, emulsifiers, diluents, and solvents, can cause plant injury. Since manufacturers often change formulations, it is possible that plant injury may occur, even though no injury was noted in previous seasons.

SUMMARY OF REDUCED CHEMICAL METHODS OF MANAGING SELECTED DISEASES OF
BACKYARD FRUIT TREES

-- SPRING AND SUMMER--

Disease	Product or Method	Signal	When to Use	Frequency	Comments
Apple/ pear scab	General comments	Few or no sprays necessary in dry springs. All sprays are preventive only. Green tip (delayed dormant) spray most important.			
	Cultural methods	Remove fallen leaves in winter.			
	Wettable sulfur	CAUTION	1) Green tip 2) Just before petals open 3) Late bloom	1-3x	
	Copper product	WARNING		1-3x	Late application may russet fruit.
Fireblight <i>(pears, Asian pears, apples)</i>	General comments	Also attacks quince, crabapple, loquat, and <i>Pyracantha</i> .			
	Cultural methods	Cut branches >12" below infection, sterilize shears between cuts.			
	Copper product (e.g., copper sulfate, fixed copper) (>50% copper)	WARNING	Bloom period	Every 4-5 days thru bloom	Spray <u>only</u> if fireblight has been a problem in past years. Begin treating when avg. temp. >60F. Late application may russet fruit.
Brown Rot <i>(stone fruits and almonds)</i>	General comments	Few or no sprays necessary in dry springs.			
	Cultural methods	Remove mummified fruits. Thin fruit in April for air circulation.			
	Copper product (e.g., copper sulfate, fixed copper) (>50% copper)	WARNING	1) Bud swell 2) Full bloom 3) Petal fall 4) Before harvest	1-3x	Spray #1 also for peach leaf curl. Spray #2 & 3 during wet springs. Sprays #2 & 3 may russet fruit. Spray #4 if spring infection severe. Sprays after bloom may russet fruit.
	Wettable sulfur	CAUTION	same	1-3x	Do not spray w/in 30 days of oil.
Grape powdery Mildew	Wettable sulfur, dusting sulfur	CAUTION	Budbreak to 2" thru berry softening	Every 7-10 days	Use 10-day interval during cold or very hot weather. All sprays are preventive only. Can use wettable in early season, dusting later. Do not use when temperature >90°F.
	Garden Fungicide	CAUTION	same	same	Sulfur+surfactants (Safer® brand)
	Neem oil	CAUTION	same	same	Do not spray within 30 days of sulfur.
Bunch Rot <i>(grape)</i>	Cultural methods	Remove leaves around clusters in early June for air circulation. Use two-wire trellising and mid-season hedging of shoots for air circulation. Avoid sprinkling vines. Avoid excess nitrogen fertilization. Remove & destroy infected clusters.			

SUMMARY OF REDUCED CHEMICAL METHODS OF MANAGING SELECTED
INSECT AND MITE PESTS OF BACKYARD FRUIT TREES

-- SPRING AND SUMMER--

Disease	Product or Method	Signal	When to Use	Frequency	Comments
Coddling Moth	General comments	Usually 3 generations; treat only 1st generation unless populations high. Monitor degree days and/or fruit; spray during egg hatch period.			
	Cultural methods	Attach cardboard bands early May, remove late May, kill larvae/pupae. Also attach cardboard in August, remove & burn late fall. Can bag fruit & use mass trapping.			
	Narrow range oil	CAUTION	Egg hatch period(s)	3-5x per generation	Do not use within 2 mo. of sulfur application (causes leaf burn). Not as effective as Sevin.
	Sevin (carbaryl)	CAUTION		1x	Use only as last resort. Kills beneficials; may increase mites. Apply at petal fall. Applying during bloom may thin fruit.
Peach Twig Borer <i>(peach, nectarine)</i>	General comments	Look for hibernacula (frass in crotches) in winter to identify.			
	Bacillus thuringiensis (Bt)	CAUTION	1) Early bloom 2) 1 week later	2x	Kills young larvae feeding on new shoots.
Scale insects <i>(decid. fruits and nuts)</i>	Summer oil	CAUTION	Crawler stage	1-2x	Control ants with tanglefoot. Apply double-sided sticky tape to twigs late April, monitor weekly to determine crawler stage. Better to control in dormant season.
	Insecticidal soap	CAUTION	Crawler stage	1-2x	
	Neem oil	CAUTION	Crawler stage	1-2x	
Calif. Red scale <i>(citrus)</i>	Narrow range oil	CAUTION	summer	1x	Oil spray directed at crawlers and immature scales.
Aphids <i>(decid. fruits and nuts)</i>	General comments	Most serious on plums. Watch for natural enemies. Use dormant spray for aphid eggs.			
	Cultural practices	Tanglefoot on trunk if have ants. Avoid excess nitrogen fertilization.			
	Forceful water spray		Control often necessary in early spring only; treat before leaves curl.	Re-treat only if populations increase again.	Knocks off aphids & honeydew; Spray early AM to allow to dry.
	Pyrethrins	CAUTION			Do not use on water-stressed plants or when the temperature exceeds 90°F.
	Insecticidal soap	CAUTION			
	Narrow range oil	CAUTION			
	Neem oil	CAUTION			
Other insecticides	variable	Chemical control usually not necessary; use other methods first.			
Cultural practices	Avoid dusty conditions and broad spectrum insecticides (especially Sevin).				
Two-spotted spider mite <i>(decid. fruits and nuts)</i>	Forceful water spray		Late spring & summer	As needed	Knocks off mites; Spray early morning to allow to dry.
	Insecticidal soap	CAUTION	Summer	1x	Treatments rarely necessary for backyard trees.
	Narrow range oil	CAUTION	Summer	1x	



Sheep: Sustainable and Organic Production

By Margo Hale,
Linda Coffey
NCAT Program
Specialists

Ann Bartlett,
Chelsey Ahrens
NCAT Interns
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This publication introduces concerns and practices specifically related to sustainable sheep production. Topics covered include breed selection, controlled grazing, pasture lambing, alternative health management, and innovative marketing of meat and wool products. A list of further resources is also included.

Introduction

For the established farmer seeking to diversify, sheep offer a number of benefits. Sheep can easily be integrated into an established farm and are a good complement to cattle. Integrating sheep into a farming operation can also contribute to the economic and environmental sustainability of the whole farm. Sheep will enhance a farm's biological diversity and may fit economic and biological niches that would otherwise go unfilled. The relatively small investment required, and the gradually increasing size of the flock, also make sheep production a good choice for beginning, small-scale, or part-time farmers.

It is important to learn as much as you can before beginning a sheep enterprise. General sheep production information — such as feeding, breeding, and health management — is available in local or state Cooperative Extension Service publications. The **Resources** section at the end of this publication provides further sources of information, including books, magazines, websites, and organizations. We strongly encourage you to supplement your reading by contacting and visiting sheep producers in your area.

Sheep can be incorporated into existing grazing operations with goats, cattle, or horses. In fact, multi-species grazing is useful in increasing pasture efficiency. It has been demonstrated that grazing sheep with cattle can increase total meat production by 24% compared to raising cattle alone, and by 9% compared to raising sheep alone.



Sheep production is a good choice for beginning, small-scale, or part-time farmers. Photo by Linda Coffey, NCAT.

(Walker, 1994) See the ATTRA publication *Multispecies Grazing* for more information.

Breed selection

Breed selection is based on the intended market(s), on local climate, and personal preference. Breeds can be divided into eight categories.

What breed(s) you choose to work with will depend on your needs and interests. Common breeds are Suffolk, Hampshire, Rambouillet, and Dorset. Hair sheep breeds include Katahdin, St. Croix, Dorper, and Barbados Blackbelly. All breeds have advantages and disadvantages. Crossbreeding is very common



Related ATTRA Publications

Small Ruminant Sustainability Checksheet

An Illustrated Guide to Sheep and Goat Production

Dairy Sheep

Breed Category	Description	Example
General purpose	Good balance between sire and dam traits	Dorset, North County Cheviot, Montadale
Maternal	Good adaptability to more difficult environments; above-average fleece; primarily found in range areas	Merino, Rambouillet, Targhee, Columbia, Polypay
Prolific maternal	Very large numbers of lambs (average three or more per ewe); excellent newborn vigor	Finnsheep, Romanov
Sire	Large mature size; rapid growth; superior muscling; lower carcass fat	Suffolk, Hampshire, Oxford, Shropshire, Texel, Southdown
Dairy	Specialized for milk production	East Friesian, Lacaune
Hair (meat)	Don't have wool; adapted to hot, humid climates; parasite tolerant	Katahdin, Dorper, St. Croix, Barbados Blackbelly
Specialized or long wool	Produce colored fleeces or fleeces with other unique characteristics; desired by fiber artists	Shetland, Icelandic, Lincoln, Border Leicester, Romney
Hobby or rare	Not typically used for commercial production; may be raised for exhibition, breeding stock, or to preserve the breed; may possess traits of importance to production in the future	Jacob, Cotswold, Navajo-Churro, Gulf Coast Native

Table adapted from "Changes in the Sheep Industry in the United States." 2008. National Research Council. Chapter 2.

and allows for lambs to have desirable characteristics of more than one breed. Your farm goals should dictate what breed(s) of sheep you choose and whether or not you crossbreed. It is also important to remember that there is just as much variation among animals of the same breed as there is among animals of different breeds.

For more information on the various breeds, contact the American Sheep Industry Association (www.sheepusa.org) or visit the Oklahoma State University livestock breeds web page (www.ansi.okstate.edu/breeds/sheep). The book *Storey's Illustrated Breed Guide to Sheep, Goats, Cattle, and Pigs*, by Carol Ekarius, is another good source of breed information. The American Livestock Breeds

Conservancy (www.albc-usa.org) has information on rare and heritage breeds. For more information and research on hair sheep breeds, see the proceedings of the Hair Sheep Workshop (www.sheepandgoat.com/HairSheepWorkshop).

When selecting animals for your flock, you must first decide what traits are important to you and what the animals will be used for. Find producers with the types of animals that you are interested in. You can locate producers by contacting your local extension agent, searching classified ads in sheep publications, viewing online directories, contacting sheep clubs or associations, or by attending meetings or seminars for sheep producers. Once you have found a producer with sheep for sale, visit the farm to observe the flock and the management. The animals will adapt more easily to your farm if their prior management and environment are similar to yours.

To develop a productive flock, it is imperative that you select healthy animals. Never build your flock with animals from a sale barn. These are often animals that have been culled by another producer. There is a reason why they were culled, and you do not want

Wooled Sheep Considerations	Hair Sheep Considerations
Growth and carcass characteristics Accepted in the traditional markets Produce marketable wool Widely available	Less seasonal than woolled sheep Higher lambing percentages than many woolled breeds Some breeds show resistance to internal parasites Heat tolerant No wool to shear or market Don't have to dock tails

to bring those problems to your flock. Don't purchase animals that are limping, look sick, or are lagging behind the others. Always purchase animals that are lively and look alert. Select animals that have sound feet and legs and a proper bite (not over-shot or under-shot). It is helpful to bring an experienced sheep producer to assist you in selecting animals that are likely to be healthy and productive.

Listed below are some of the signs of a healthy animal.

- Lively manner
- Easy movement (no limping, swollen joints, or misshaped or hard udders)
- Proper conditioning (not overly fat or excessively thin)
- Well-shaped udder and teats

Question the producer about the flock. For example, ask what diseases have been problems in the flock, what the vaccination and deworming protocol is, and what criteria are used for selection and culling. Also ask your veterinarian about diseases that could be a problem in your area.

To run an efficient operation, it is necessary to identify animals (usually by tattoos or eartags) and keep records. Breeding, reproduction, health, and production records are helpful in identifying which animals are most productive and which should be culled. Sample record-keeping forms can be found at www.sheepandgoat.com.

Feeding ruminants

Sheep will typically consume two to four percent of their body weight (on a dry matter

basis) each day in feed. Animal size, stage and level of production, animal activity, and environmental conditions all influence an animal's nutritional requirements. A variety of feedstuffs can be used to meet your animals' nutritional needs.

Forage from brush, pasture, and range can be maximized as low-cost feeds. Sheep, as ruminants, convert forage that would otherwise be unusable into high-quality fiber, meat, and milk. Like cattle, sheep are grazers; like goats, they also consume woody browse (tree forage and shrubs) and forbs (herbaceous plants). Sheep are less dependent on harvested grains than dairy cattle, swine, and poultry.

Sheep are ruminants, named for the rumen — the largest compartment of the stomach. The health and productivity of sheep, as with all ruminants, depends on healthy rumen function. Microorganisms in the rumen digest fiber, carbohydrates, and protein to supply the animal with nutrients. It is essential that the animals be fed appropriately so that these organisms stay healthy.

The rumen organisms require fiber, nitrogen (protein), and energy (carbohydrates). The microorganisms prefer a pH range of 6 to 6.8. The digestion of grain (especially finely ground grains) lowers the rumen pH. If sheep eat too much grain, their ruminal pH can drop too low and make them very sick. The rumen microorganisms are healthiest when sheep are eating high-quality forages such as vegetative pasture. When grain (or more grain) is added to the ration, the rumen needs time to adjust. For more information, see ATTRA's *Ruminant Nutrition for Graziers*.

Lambing						
Animal ID	Bred	Due	Lambled	No. in litter	Sire	Comments

An example breeding record form.

Pastures: Sustainable
Management

Pasture, Rangeland,
and Grazing
Management

Ruminant Nutrition
for Graziers

Rotational Grazing

Paddock Design,
Fencing, and Water
Systems for
Controlled Grazing

Managed Grazing
in Riparian Areas

Pasture grazing

Improving pasture and extending the grazing season are important in forage-based sheep operations. Depending on the climate, it may be possible to improve pastures with cool season perennials (tall fescue, orchardgrass), warm season annuals (crabgrass, dwarf pearl millet), cool season annuals (annual ryegrass, oats, wheat), and a few warm season perennials (bahiagrass, bermudagrass) to provide year-round forage. The addition of legumes (alfalfa, clover, lespedeza, birdsfoot trefoil) to a pasture provides high-quality protein and reduces the need for nitrogen fertilizer. Sheep may also be pastured on small grains or root crops (brassicas). Feeding harvested products such as hay and concentrates (grain) is usually a higher-cost practice. The term “grass-farming” reflects the understanding that the livestock grazer’s primary product is high-quality pasture, the prerequisite for healthy animals and healthy profits. For more information on pastures, see ATTRA’s *Pastures: Sustainable Management*.

The best grazing system for efficient use of pasture is controlled grazing, or management-intensive rotational grazing. In controlled grazing, pastures are divided into smaller units called paddocks. The sheep are kept in

a paddock until they have grazed the forage down to a predetermined height, and then rotated to the next paddock. They are not returned to a paddock until the plants have regrown to the height needed for availability and quality. Sheep prefer to eat forage no taller than six inches; forage should be grazed no lower than three inches. Controlled grazing reduces both selectivity and repeated grazing pressure — letting plants develop more foliage before being grazed again — while increasing pasture diversity. Although rotational systems require initial expenditures for fencing and water facilities, many producers report increased profitability based on lower input and feed costs, less dependence on machinery, and improvement and better use of pasture.

When grazing sheep, farmers must protect their pastures from being overgrazed. There are several reasons for this. Overgrazing forages:

- Eventually kills the plants
- Reduces the longevity of the stand and exposes more soil to erosion
- Means the animals don’t get enough food
- Increases the chance of sheep ingesting infective internal parasite larvae

Environmental impacts and sustainable sheep production

There are substantial environmental benefits associated with sustainable sheep production. These include low embodied energy in feed — all the energy used during feed production — and low releases of emissions such as carbon dioxide (CO₂), nitrous oxide (N₂O) and methane (CH₄).

Generally, sustainable sheep production is pasture-based and requires little or no supplemental feed. Producing forage on-site and without the use of energy-intensive inputs including fertilizers, herbicides, and fuels to dry and store feed, generally lowers the embodied energy in sheep feed. When feeding native hay and grains that are produced locally, the energy required

for transportation is reduced further due to shorter distances between the feed source and the sheep. Since fossil fuels are primary sources of greenhouse gas emissions such as CO₂, using fewer energy inputs usually reduces emissions as well.

Providing sheep with access to pasture forage improves the ecological balance between forage and livestock. Pastured sheep efficiently close the loop between harvesting forage and returning nutrients to the soil, and with less energy than if forage were harvested and hauled from the pasture and manure was then hauled back out onto the pasture. Distributing manure and urine on the pasture

also reduces methane emissions from manure slurry.

Proper soil and pasture management can also mitigate the release of emissions. Under certain soil conditions, N₂O emissions are released from the soil through a process called denitrification. An excessive buildup of manure and urine (nitrogen, ammonium) in water-saturated soils can lead to denitrification and the release of N₂O, a greenhouse gas 310 times more powerful than CO₂. Rotating animals through pastures and moving feeding, watering, and shade areas will help spread the manure and urine out more uniformly and may help decrease N₂O emissions from pasture soils.

- Creates bare spots, creating opportunities for undesirable weeds and erosion.

The end result of overgrazing is reduced performance of both the pasture and the animals, as well as health problems for the animals. To prevent overgrazing, farmers should be careful to understock rather than overstock land and always remove animals from a pasture when the pasture is grazed down to about three to four inches.

Fresh, clean water must always be available. Adult sheep require approximately one gallon of water per day. In a rotational grazing system, the animals either have access to a central water source available to every subdivision, or water is provided separately to each of the pasture's subdivisions. This can be a challenge and an additional capital expense. For more information, see ATTRA's *Pasture, Rangeland, and Grazing Management*.

Predation

Sheep are animals of prey due to their size and nature, so they are susceptible to predation. Predators range from coyotes and mountain lions to neighborhood dogs. The first line of defense should be strong, adequate fencing. But most of the time fencing is not enough. Livestock can be protected by guardian animals, including donkeys, llamas, and most commonly, guardian dogs. The most widely used livestock guardian breeds are Great Pyrenees, Anatolian Shepherds, Komondors, and Kuvaszes. For more information on how to control predators, see the ATTRA publication *Predator Control for Sustainable and Organic Livestock Production*.

Range grazing

Rangeland is land historically dominated by grasses, forbs, or shrubs. Rangeland also includes land revegetated and managed like native vegetation. Some rangeland types are natural grasslands, savannas, most deserts, tundra, alpine plant communities, coastal and freshwater marshes, and wet meadows. (USDA, 2003) The natural diversity, topography, climate, and extent of rangelands in the U.S. make rangelands well-

Fencing

When raising sheep on pasture, adequate fencing is essential. Good fencing allows you to control grazing, helps save you the frustration of having to chase sheep back into the pasture, and helps protect against predators. Fencing will also be the greatest expense, other than the initial cost of the animals. Traditional sheep fencing is a four-foot woven wire with barbed wire along the top. Four or more strands of high-tensile electric wire is a more economical fencing choice. Strands of polywire can be used for temporary paddocks. Sheep may have to be trained to electric fences by placing them in a small paddock to "test" the wire. Electric netting is also an option for temporary fencing in controlled grazing systems. Regular checking and testing of fences is necessary, and any problems must be fixed promptly, or sheep will escape. Sheep will respect electric fencing better if it is hot (>3000 volts).

These animals are hardest to fence:

- Rams
- Lambs at weaning
- Hungry sheep (not enough forage in their pasture)
- Sheep in full fleece



Photo courtesy of Susan Schoenian, University of Maryland

sited to sheep grazing. However, rangelands have historically been over-exploited to the detriment of many range sites, especially in the western U.S. Nowadays, range managers and researchers are making significant inroads toward the development of sustainable rangeland grazing systems that are naturally regenerative; allowing for the production of livestock while restoring sensitive rangeland.

About 48% of sheep produced in the U.S. are raised in 10 western rangeland states. (NASS, 2010) Sheep are well adapted to



A Great Pyrenees guards his flock. Photo by Susan Schoenian, University of Maryland.



Sheep are well adapted to rangeland grazing. Photo by Susan Shoenian, University of Maryland.

Copper

Sheep are very sensitive to copper. They require lower levels than other livestock. Be sure to feed mineral mixes and other feed products that have been specifically formulated for sheep.

rangeland grazing because of their body size relative to cattle, their grazing and browsing behavior that relies on a more diverse diet than cattle, and, especially, their ability to graze weedy plants such as leafy spurge and spotted knapweed.

Range managers have known for years that grazing can damage rangeland health for decades. Through observation of rangeland ecology and grazing animal behavior, successful grazing managers realize that animal impact can have a positive influence on rangeland health as well.

A good example of management to positively affect rangeland health is called targeted grazing. According to Launchbaugh and Walker (2006), targeted grazing is the application of a specific kind of livestock at a determined season, duration, and intensity to accomplish defined vegetation or landscape goals. As opposed to good grazing management, which range managers are becoming quite good at, targeted grazing refocuses the results of grazing from livestock production to vegetation and landscape enhancement. (Launchbaugh and Walker, 2006)

For more information on targeted grazing and using sheep to control weeds, see the publication *Targeted Grazing: A Natural Approach to Vegetation Management and Landscape Enhancement* (www.cnr.uidaho.edu/rx-grazing/Handbook.htm).

Supplemental feeding

Wintertime or dry-period feeding may include supplements in addition to hay. Grain (corn, barley, oats) is used as a supplement to provide energy. Soybean or cottonseed meal is used to provide protein. Other potential feedstuffs include crop residues such as cornstalks, crops spoiled by wet weather, cull vegetables, and by-products from cereal milling, wheat milling, and food processing.

Trace-mineralized salt or other mineral supplements are also needed. It is best to feed calcium, phosphorous, and trace minerals in the grain or in a salt mixture to ensure that the animals actually eat them. Test your

forages to determine their mineral content, and adjust mineral supplementation as needed. Your local Extension agent can have your forage analyzed. Mineral content of forage is quite variable across the country, and the type, stage, and level of production of the animal influences mineral requirements. Therefore, no one mineral supplement formula is right for all locations or situations. It is very important that you consistently offer mineral mix (preferably in a loose form), monitor its consumption, and ensure that all the sheep are in fact eating adequate amounts of the mineral supplements. The website www.sheepandgoat.com has additional resources on proper nutrition and feeding of sheep.

Ration-balancing ensures that animals receive the necessary amounts of nutrients (energy, protein, vitamins, and minerals). By using the National Research Council's The Nutrient Requirements of Sheep (see References) and their chart of the nutrient make-up of various feedstuffs, a producer can determine the amounts of nutrients their sheep should receive. If laboratory feed analysis is available, it should be used instead. Advice from a local Extension agent can be helpful in balancing least-cost rations. Montana State University has a website for balancing sheep rations, www.msusheeppraction.montana.edu.

Body condition scoring

Your goal in feeding your animals is to meet their nutritional requirements (economically) and to keep them in a productive condition. One way to monitor the animals' condition is to assign body condition scores (BCS). Body condition scoring evaluates the body fat reserves of your sheep and is an easy method to evaluate the effectiveness of your feeding program. To do this with sheep, you must use your hands to feel the animal — wool and hair make it impossible to see accurately.

Body condition scoring is based on the amount of muscling and fat deposition over and around the vertebrae in the loin region. Scores range from 1 to 5, with 1 being emaciated and 5 being obese. For most of the life cycle of the sheep, the goal is to keep them in moderate condition (3). When ewes are nursing twins some weight loss is expected. Even with good feed, body condition may be a 2.

It is a good idea to monitor the body condition of your flock before breeding, before lambing, after lambing (while nursing), and at weaning. You should adjust your feeding program to allow most of your flock to maintain moderate condition. Body condition scoring can also be used to determine market readiness.

Body Condition Scores	
Score 1	<p>Sheep is extremely thin, unthrifty but agile.</p> <p>Skeletal features are prominent with no fat cover.</p> <p>No apparent muscle tissue degeneration.</p> <p>Has strength to remain with the flock.</p>
Score 2	<p>Sheep is thin but strong and thrifty with no apparent muscle structure wasting.</p> <p>No evident fat cover over the backbone, rump, and ribs, but skeletal features do not protrude.</p>
Score 3	<p>Sheep are thrifty with evidence of limited fat deposits in fore rib, over top of shoulder, backbone, and tail head.</p> <p>Hipbone remains visible.</p>
Score 4	<p>Moderate fat deposits give the sheep a smooth external appearance over the shoulder, back, rump, and fore rib.</p> <p>Hip bone is not visible.</p> <p>Firm fat deposition is evident in brisket and around the tail head.</p>
Score 5	<p>Sheep are extremely fat with the excess detectable over the shoulder, backbone, rump, and fore rib. Excess fat deposits in brisket, flank, and tail head regions lack firmness.</p> <p>Sheep appear uncomfortable and reluctant to move about.</p>

Table adapted from the "Sheep Production Handbook." 2006.

How many rams do you need?

You should have one mature ram for every 35 to 50 ewes. Ram lambs (7 to 12 months) can service 15 to 30 ewes.

Reproduction

Breeding

Female sheep (ewes) reach puberty between 5 and 12 months of age, depending on the breed and nutrition of the ewe, and should be at least 70% of their mature weight at breeding. Most sheep are seasonal breeders, reacting to shorter days as a cue for breeding. The presence of a ram stimulates the reproductive cycle (estrus). The typical peak time for breeding is the fall (October-November), and ewes come into heat every 16 to 17 days. Gestation is about 150 days.

Breeding and lambing should be planned based on many factors including the following.

- Market demands (What type and size of animal will you market and when?)
- Available forage
- Timing (Do you want to lamb in January or March?)
- Production system (Do your animals breed out of season; do you want multiple lamb crops in a year; are you lambing on pasture or in a barn?)
- Climate (Is shelter available?)



Optimum lambing time varies depending on the production and marketing situation. Photo by Linda Coffey, NCAT.

While the ram is often overlooked, he is the most important member of the flock. Your ram influences every lamb in your flock. Having a quality ram, with the traits you want, is important to building a productive flock.

Rams reach puberty between five and seven months, at approximately 50% of their mature weight. It is wise to have a breeding soundness exam (BSE) performed on your ram. A BSE can be conducted by your veterinarian or other trained professional. The exam consists of a physical evaluation of the ram (lameness, body condition, general health, scrotal circumference) and semen evaluation (sperm count, motility, and morphology). It is also important to observe rams for breeding behavior. A breeding soundness exam will not indicate libido. You can use a marking harness to assess breeding behavior and effectiveness. Exposure to high temperatures can cause a ram to be temporarily sterile (up to 10 weeks). Shade and shearing can help keep rams cool.

Males of breeding age are unpredictable and may be aggressive. Rams should never be trusted, even if they were hand raised. In fact, hand-raised rams can be more dangerous because they lack fear or respect for humans. Behaviors that were fine when they were small (butting, rubbing) can be dangerous in a full grown ram. Never turn your back on a ram. If you are raising rams, don't touch their heads, and don't try to make them pets.

Lambing

In general, ewes will lamb with no assistance and with no problems. Good nutrition and plenty of exercise will prevent many birthing problems.

Lambing can be done in sheds or barns or on pasture. Pasture lambing reduces the need to invest in buildings and equipment and is more appropriate for low-input systems. Southern flocks will have less difficulty with inclement weather than those in colder climates. Disease occurrence may be lower with pasture lambing than with shed lambing because disease agents are not concentrated as they are in confinement. Disadvantages

of pasture lambing include greater risks of parasites and losses from bad weather and predators.

Optimum lambing time varies depending on the production and marketing situation. By timing lambs to be born around the same time as the spring flush of growth in the pasture, ewes can have adequate forage during their peak period of lactation. This will also cut down on the supplemental feed ewes need. However, some producers have noted that lambs born later in the spring do not grow as well as lambs born earlier, which may be due to parasites. Lambs born later are just starting to graze as parasite numbers on pasture are increasing. Earlier lambs have a chance to grow and develop their immune systems before they have the parasite pressure of spring and summer grazing. If lambing occurs early in the year (January to early March), ewes will need high quality hay and possibly other supplements to meet the needs of lactation. Evaluating your costs may help you decide on the best lambing season for your farm.

Lamb management

It is crucial that newborn lambs receive colostrum (first milk) as soon as possible (ideally, in their first 12 hours). Monitor lambs to make sure they are nursing and have bonded with the ewe. It may be necessary to remove a lamb(s) from the ewe if she does not have enough milk for her lambs. Ewes should have enough milk for twins, but some ewes might not be able to raise triplets or quadruplets. Lambs that have had enough milk feel heavy when you lift them, with slightly rounded bellies. They will seem content after nursing and strong, lively, and playful. Lethargic lambs or crying lambs may be a sign they are not nursing or are not getting enough milk. Starvation is a leading cause of death in the first two days of a lamb's life.

It is important to monitor lambs for health issues such as coccidiosis and internal parasites. For information on castration and tail docking, see ATTRA's *Illustrated Guide to Sheep and Goat Production*. Growing lambs

need high quality forage. In a rotational grazing system, let weaned lambs graze a pasture first. This will ensure they are getting quality forage and also grazing pastures with lower parasite numbers.

Health

Starting with healthy sheep and properly maintaining them with adequate nutrition and clean living conditions will prevent most health problems. In addition, vaccinations and low stress handling will assist in keeping a flock healthy. Observe your animals and respond quickly to any health problems — isolate animals at the first sign of illness. Indications of a sick sheep include lethargy, isolation from the flock, loss in body condition, abnormal manure, runny nose, and huddled posture. It is important to have a working relationship with a veterinarian. A veterinarian can help with preventative care and proper treatment of disease. To locate a veterinarian who works with sheep, contact the American Association of Small Ruminant Practitioners: (334) 517-1233, www.aasrp.org.

Even with proper management, sheep will sometimes have health problems. Keeping health records will help you to identify animals that have repeated health problems. Culling those animals will result in a stronger flock. The following is an overview of some common health problems that affect sheep.

Internal parasites

For many sheep producers, especially those in humid climates, internal parasites will be the primary health concern. Animals with severe internal parasite loads will be unthrifty, won't gain weight, are often anemic, and may die. Due to overuse of dewormers and parasites' increasing anthelmintic resistance, management of internal parasites is a complex problem. Sheep producers must be knowledgeable about internal parasites, and they must have a plan to prevent and manage parasite infections. Because of the complex nature of internal parasites, managing them will take an integrated approach. A combination of treatment and management

Related ATTRA Publications

Managing Internal Parasites in Small Ruminants

Tools for Managing Internal Parasites in Sheep and Goats: Copper Wire

Tools for Managing Internal Parasites in Sheep and Goats: Sericea Lespedeza

Integrated Parasite Management for Livestock

is necessary to control parasitism so that it will not cause economic loss to the producer.

Parasite management tools may include the following:

- Pasture management
 - * Use pasture rotation with adequate rest periods.
 - * Employ multi-species grazing.
 - * Provide taller forages and browse.
 - * Put susceptible animals (lambs) on pasture before mature animals.
- Animal selection
 - * Use breeds and animals that show resistance to parasitism (pay special attention to rams).
 - * Cull animals that are frequently “wormy.”
- Selective deworming (only treating animals that need it)
 - * Use FAMACHA[®] to identify wormy animals. FAMACHA[®] is a system for classifying animals into categories based upon levels of anemia (a sign of *H. Contortus* infection).
 - * Be alert to other physical signs of parasitism and deworm as needed.

- Strategic deworming
 - * Deworm ewes at lambing time.
 - * Treat lambs because they have little resistance.
 - * Deworm all new animals.
- Effective use of dewormers
 - * Use the Smart Drenching technique. (www.scsrpc.org/SCSRPC/Files/Files/Misc/DRENSHIN.PDF)
- Novel treatments
 - * Treat animals with copper wire boluses.
 - * Provide forages containing condensed tannins (*sericea lespedeza*).

For more information on managing internal parasites, see ATTRA's *Managing Internal Parasites in Small Ruminants* and visit The Southern Consortium for Small Ruminant Parasite Control website: www.scsrpc.org.

Foot rot

Foot rot is a contagious disease caused by bacteria that affect the horny hoof tissue. Once foot rot is introduced into a flock, it is very difficult to eradicate. Foot rot is spread from an infected sheep to the ground and bedding, where it is picked up by uninfected sheep. Foot rot is characterized by limping animals and pockets of foul-smelling infection in the hoof. Other things can cause limping; have your veterinarian examine the animals if you are unsure of the cause of limping.

Foot rot can easily be prevented by not introducing it to your flock. Never buy a limping animal or one from a flock with any limping animals. Don't purchase sheep from sale barns. Practice good biosecurity; isolate new purchases for 30 days and examine their feet during that time; wear boot covers when visiting other sheep producers and have them do the same. Cull animals with repeated foot rot problems.

Hoof trimming and foot baths are common treatments for foot rot. All affected hoof tissue should be trimmed away. Remember to disinfect the trimming tools between animals



Animals will pick up more parasite larvae when they graze forages shorter than four inches. Photo by Linda Coffey, NCAT

to prevent spreading the infection. Foot baths of zinc sulfate or copper sulfate solutions can be used to treat foot rot. For help with hoof trimming and foot bath solutions, contact your veterinarian. There is a foot rot vaccination that has shown some success in prevention and treatment, but it is not 100% effective.

Scrapie

Scrapie is a fatal, degenerative disease affecting the central nervous system of sheep and goats. It is among a number of diseases classified as transmissible spongiform encephalopathies (TSE). Signs of scrapie include weight loss despite retention of appetite, itching and rubbing, loss of coordination, and death. In the U.S., scrapie has been diagnosed mostly in Suffolk sheep and their crosses.

The U.S. has had some form of a scrapie eradication or control program in place for many years. As part of the National Scrapie Eradication Program (www.aphis.usda.gov/animal_health/animal_diseases/scrapie), all states require most sheep and goats to be officially identified on change of ownership. And, while many states have requirements identical to the USDA interstate requirements, other states have additional requirements regarding intrastate movement and/or interstate movement. Some states exempt certain classes of sheep and/or goats. For information on your state's scrapie identification requirements, see www.eradicatescrapie.org/State%20ID%20Requirements.html.

OPP

Ovine progressive pneumonia (OPP) is a virus that generally affects only sheep over the age of two. OPP is spread through the ingestion of infected colostrum and milk. Signs of the disease are primarily seen in mature sheep. Early signs of OPP are weight loss while maintaining a normal appetite and intolerance to exercise. Other signs are labored breathing, hard udder, and lameness. OPP can be diagnosed through a blood test. There is no treatment for OPP. Animals testing positive should be culled from your flock. For more information, see www.oppociety.org.

Contagious Ecthyma

Contagious ecthyma (commonly called sore-mouth or orf) is caused by a virus. Infected animals will develop sores and scabs on their lips and mouths and occasionally on the udders and teats. The virus can remain infectious in the scabs for long periods. Once an animal has been infected, it is generally immune to further infections. Because soremouth is a virus, antibiotics are ineffective; you have to let the virus run its course. This virus can be passed to humans; always wear gloves if you handle animals with soremouth. There is a vaccine, but if you have not had soremouth in your flock, it is better not to vaccinate because the vaccine contains a live virus. For more information, see www.sheepandgoat.com/articles/soremouth.html.

Caseous Lymphadenitis (CL)

Caseous lymphadenitis (CL) is caused by a bacteria that causes abscesses on the lymph nodes and internal organs. The bacteria are usually introduced through a wound or abrasion. The clinical signs of the disease are one or more abscesses that are often located just beneath the skin, usually around the jaw and neck. However, if organisms enter the bloodstream, abscesses may also develop in internal organs such as the lungs or liver. In this case, external abscesses may not be present, and the only noticeable symptom is a thin, debilitated animal. The abscesses contain a thick, yellow to white pus that has a soft, pasty consistency, much like toothpaste.

CL does not respond to antibiotics because antibiotics cannot penetrate inside the abscess. Abscesses can be surgically drained and flushed with an iodine solution. However, draining the abscess will increase risk of transmission of the organism to other animals if they are exposed to the pus. The discharge that is present in the abscess should be disposed of in such a way as to avoid contamination of the facilities and remaining animal population. In sheep, abscesses are usually not found until shearing. During shearing, the shearer may inadvertently nick the wall of an abscess. If this occurs, shearing should be stopped, and the clippers, blades and general

area should be disinfected as well as possible.

Currently, one company manufactures a vaccine for the prevention of CL. This vaccine is called Case-Bac®, and it is manufactured by Colorado Serum Company. A study published in the Journal of the American Veterinary Medical Association showed a significant reduction in the number of abscesses when sheep were vaccinated. (Washburn et al., 2009)

Mastitis

Mastitis is an inflammation of the mammary gland and may result in reduced production and profitability. It is usually caused by the bacterium staphylococcus or streptococcus, but it can also be caused by other bacteria. Symptoms include pain, heat, redness, swelling, and a hard udder. Ewes will not always show physical symptoms of mastitis. A ewe with mastitis may not let her lambs nurse. Lambs that aren't growing and thriving may be an indication of mastitis in their dam. Streptococcus infections are responsive to antibiotics and are fairly easy to eradicate. Staphylococcus infections do not respond well to antibiotic treatment. Mastitis may also be the result of injury.

Vaccinations

Vaccinations can be important to your flock's health plan. Simple vaccinations can prevent many diseases that affect sheep. The most common sheep vaccinations are those that protect against clostridial diseases. A CD-T vaccine protects against enterotoxemia caused by *Clostridium perfringens* types C and D and tetanus caused by *Clostridium tetani*.

There are many other vaccinations available. Contact your local veterinarian to discuss other vaccinations based on your flock's health and local disease problems.

Record keeping

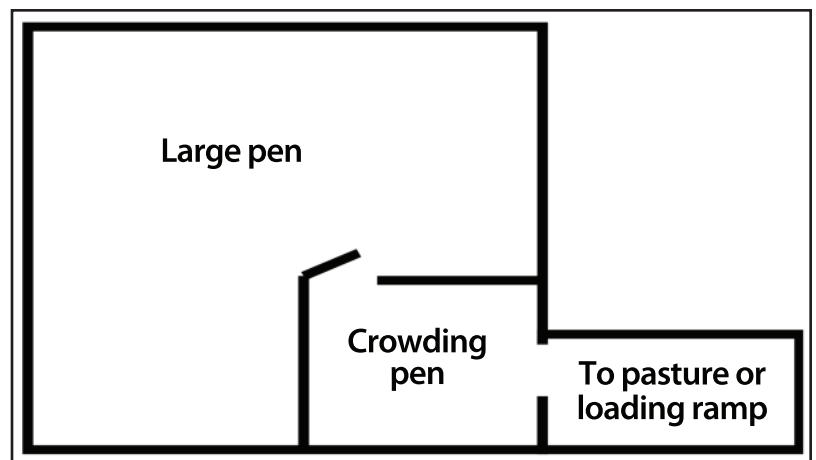
Record keeping is a vital part of your flock's health program. It is important to keep records of sick animals, treatments administered, and note milk and meat withdrawal times. Good records can help you choose animals to cull.

Facilities

Sheep don't require extensive housing or facilities. You should provide shelter from cold, rainy weather and shade in the summer. Buildings used for shelter may be minimal, but they should be well-ventilated and clean. Barns and sheds are not the only options. There are portable shelters and moveable shades, and even old hog huts can be used as shelters for your animals.

There are many options for handling facilities. While there are many elaborate systems available, a simple gathering area and chute or alleyway is all that is needed for most small operations. Having a useable handling system makes tasks such as sorting, weighing, vaccinating, or FAMACHA® scoring much easier. A scale is an important piece of equipment because knowing the weight of your animals aids in marketing, tracking weight gains, and calculating proper medicine and deworming doses.

For more information on shelters, equipment, and fences, see ATTRA's *Illustrated Guide to Sheep and Goat Production*.



An example of a simple handling set-up. Diagram by Susan Schoenian, University of Maryland.

Handling sheep

Sheep raised in close contact with people experience less stress when being handled.

Tips for proper handling:

- Be calm and patient
- Do not probe or force livestock.
- Move slowly and deliberately.
- Talk softly and in a low tone.
- To restrain sheep, hold them under the chin, with a halter, against a fence or gate, or straddling them.
- Be careful of horns and sudden movements.

List adapted from a presentation by Susan Schoenian, University of Maryland (www.sheepandgoat.com).

Marketing

While there are many opportunities for marketing sheep and sheep products, there are also many limitations. Options may be limited by regulations, access to processing, or access to an adequate market. There are many more options than just taking your sheep to the sale barn. How you choose to market your animals will depend on many things, including personal preferences and market demands.

Sale Barn

Taking sheep to a local auction is one of the most common methods used by producers. There are advantages to this method: it is quick, it requires little effort by the producer, and most auctions are bonded, which means you will be paid within 24 hours of sale. The biggest disadvantage is that you have no control over the price. There are a few things producers can do to get the best price for their animals at an auction.

- Do not just show up; contact the auction manager, describe your flock, and ask him when the best day to come to his auction would be. He should be helpful and show

interest in acquiring your business. If he is not, choose another auction.

- Ask if you can bring your animals the day before and if hay and water are available. Ideally, they will be presented earlier in the auction, but at the least will be acclimated to the environment and look nicer for the sale.
- Find out whether there are any auctions in your area that will allow you to set a floor price.
- Stay for the auction; don't just drop the animals off. An auction is a great place to make connections and find future customers. Talk to the buyers about what they are looking for, and tell them about your operation.
- Try not to restrict your marketing to auctions alone, because they can be very risky.

Pooled sales

There are several ways to cooperate with other producers to sell large volumes of animals and receive a better price than at a traditional sale barn. A pooled sale is where you work with a buyer who wants a large volume (semi-trailer load) of animals. The buyer will tell you what type and size of animals he needs (e.g., 100-pound lambs). You can then work with other producers to complete his order and bring all of the animals to a central location. The benefit of this type of sale is you will usually know what the buyer will pay prior to selling the animals. If the price is not high enough to cover your costs, you can choose not to participate. It is very important to meet the criteria that the buyer sets. If he asks for 100-pound lambs and you bring 75-pound lambs, the buyer won't be happy, you won't receive the set price, and the buyer may not agree to work with you again. Pooled sales do take a great deal of organization, since you will have to find a buyer, determine the needs of the buyer, and coordinate with other producers.



There are many options for marketing sheep and sheep products. Photo by Susan Schoenian, University of Maryland.

Packers, wholesalers, dealers and retailers

A meat packing business generally owns its own processing plant and buys animals to slaughter, process, and resell. A wholesaler buys animals, takes them to a slaughterhouse, and butchers them to sell to a variety of retailers. Retailers (restaurants, grocery stores) sell directly to the end customer. These people are known as “middlemen,” and they do the hard work for you, but you get a lower price for your product.

Direct marketing

Direct marketing is when producers sell their products directly to their customers. This allows the producer to bypass the “middleman” and become a “price-maker” rather than a “price-taker.”

Direct marketing options may be limited by your location and the processing available. If there is not a processor nearby, direct marketing alone is not a viable option for your operation. Direct marketing takes a lot of time, effort, communication, and intensive management. Producers must be willing to wear several hats; along with their livestock management skills, they must become businessmen, marketing agents, and salesmen. If your customers are coming to your farm, your facilities must be presentable. Provide additional information about your facility,

why your lambs are different, what their living conditions are, how they are fed, and why the customer should buy from you. You could provide a handout with information or even samples of smoked or barbecued lamb. For additional direct marketing advice and ideas, see the Direct Marketing Lamb Management Guide at www.kansasruralcenter.org/publications/DMLamb.pdf.

There are many options for selling directly to your customer:

- **On Farm:** If you are selling on farm, your facilities must be clean and presentable. Make sure your pastures are not run down and that all animals are healthy. Keep breeding stock separate from sale animals. You could offer a tour of your farm while explaining what sets it apart from others. If you have animals other than sheep, this is a good opportunity to market them and diversify your sales.
- **Live:** As with selling the whole/half lamb, selling the animal live is a good option. Many producers sell the live animal for \$1 per pound or more. Keep in mind that customers who buy a live animal do so to ensure that it is slaughtered according to their religious beliefs, and they may request a place to slaughter their animal on-site. Check state and local regulations to see whether this is permissible.
- **Whole/Half:** If you have customers who are willing to buy a whole or half lamb, this is the best option because you sell the lamb all at once and do not have to market the less-desirable cuts.
- **Cuts:** Selling cuts of lamb individually is the most time-consuming practice, but it is usually what customers want. You must have the animal processed, packaged, and labeled and have a place to store the meat. You need to determine the price of each cut, and consider making

value-added products from the remainder of the animal.

- **Farmers' markets:** Farmers' markets are great for marketing your product and meeting potential customers. However, they can be very time consuming, and you must know the regulations on bringing meat to the market. Some markets require the producer to furnish a generator and freezer if selling fresh or frozen meat, and some allow only processed meats. Regulations, fees, and licenses vary, so be sure to check with the market director and local health department.
- **Restaurants/Stores:** Restaurant and grocery store sales can be good, reliable sources of income, but these establishments are often very unforgiving. They require a consistent, high-quality, and lean product, often year-round. Be sure to have a good relationship with a quality processor if you sell directly to restaurants or stores.
- **Ethnic/Religious Groups:** Many ethnic and religious groups prefer lamb (and mutton) to other meats. If you live near an area with a diverse population, this may be a strong customer base. If you are targeting a specific group, it is important to know what type of animal they want and when. Preferences such as age, size, and sex of the animal can vary depending on the group and the holiday. For more information on marketing to ethnic and religious groups, see the following resources.

* Producing and Selling Sheep to Ethnic/Religious Markets, www.westernmaryland.umd.edu/ethnic-marketing.htm

* Ethnic Holiday Calendar 2009-2013, www.sheepandgoat.com/articles/ethniccalendar.html

* Direct Marketing Lamb to Niche and Ethnic Markets, <http://web.extension.uiuc.edu/iidea/PDF/lambfactsheet.pdf>

Processing	
There are different levels of processing, and access to them will affect how you can market your animals.	
Federal or USDA Inspected Plants	Federal plants can process meat for nationwide sale.
State Inspected Plants	Only about half of the states have a State Inspection program. State inspected plants can process any meat, but it is stamped for sale only within that state.
Custom Exempt Plants	A custom plant processes for individual use. The meat must be stamped "not for sale."
On-farm slaughter (exempt from inspection)	Animals are processed by the owner for individual use (regulations vary by state).

- **Buyers Clubs:** With a buyers club, you will pre-sell your lamb, usually a whole or half animal. You will work with the processor to meet the customer's cut preferences. You will then deliver the cut and wrapped lamb to the customer. This set-up works well if you have customers who want lamb on a regular basis.
- **Internet Sales:** The Internet is both a vast source of information and a very useful tool that costs very little. Shipping meat can be complicated and expensive, and it is often not worth the trouble. However, many people don't realize that Internet advertising can increase local sales. Whether you have your own website, advertise on a local website, or just add your business to Internet directories, such as www.localharvest.org, web advertising can be very beneficial with little or no cost to the producer. The Internet can also be a means by which current customers can invite their friends to look into your product.

Before you begin marketing, consult your local and state authorities about the regulations governing the marketing of meat products. You may need USDA inspection, permits, or licenses. There might be requirements regarding sales tax, weight, measurement, sanitation, zoning, and right-of-way. All of these regulations vary depending on the type of product you want to market (fresh, frozen, processed) and where (interstate, intrastate) you want to market it.

Sierra Farms, California, Mel and Mary Thompson

Mel Thompson and his wife, Mary, have been producing sheep in northern California for 12 years. Their family-owned operation, Sierra Farms, currently has about 350 polypay/white dorper cross ewes and 500 lambs. Both Mel and Mary have a passion for farming and have raised sheep since they were children. When they began Sierra Farms, they were selling their lambs in traditional auctions or directly to a processor. Recently, however, they have begun to find innovative ways to market their lambs directly to the public, “to avoid the middleman,” and have found other, surprising benefits in the process.

Mary has created a website, www.lambeatersconnection.com, that is a directory connecting lamb producers with consumers. The goal of Lamb Eaters Connection Directory is to provide the public with local connections to fine lamb through chefs, caterers, restaurants, wineries, producers, and retail outlets. Mary began the website in 2008, and it has picked up speed since, with people all across the country adding listings. Included in the directory are home dining recipes, buying and cooking tips, names of breeders, sources for wool fiber, and many sheep related products and activities. Mary always welcomes comments or questions about the directory.

In 2006, Mel, with a group of lamb producers, received a USDA Value-Added Producer Grant (VAPG) to develop a feasibility study and business plan for directly marketing lamb. The study and business plan identified a marketing niche that included regularly scheduled sales and deliveries to individuals in the San Francisco Bay area. After a year of ground work, sales have reached 25 to 30 lambs each month. Mel works with his processor, Superior Farms, to have the lamb processed, vacuum sealed, and boxed.

Mel spends up to four hours per day marketing, using e-mail and making phone calls. He has begun using a blog, www.sierrafarmslamb.blogspot.com, to improve information flow. His blog posts remind customers that “sustainability is a two-way street; you’re helping us, we’re helping you.” He highlights the benefits of local, pasture-raised lamb, champions direct food access and local economies and promotes source identification and lamb-husbandry education.

Mel and Mary have found direct marketing to be extremely satisfying, both for themselves and their customers. Mel has been surprised by the response from customers — their gratefulness for this direct marketing experience and for the quality of lamb they are now able to purchase.

“I come from a long line of farmers,” Mel says, “but I think I may be hearing for the first time in that history people thanking a farmer for what he is doing. It’s a stunning and humbling thing to hear.”

“I think the important message is that consumers are increasingly looking for ‘social attachment’ or definition in the common activities of their lives. The act of eating is being rediscovered or redefined, along with expectations of quality and welfare assurances. Direct marketing is the perfect opportunity to make this attachment, and a single producer should not minimize his or her individual capability to make it happen.”

By managing the farm the same way they always have (maximizing pasture efficiency by rotational grazing, reducing supplementation, providing a healthy livestock environment, and reducing stress) but changing their marketing plan, Mel and Mary are now selling high quality products to socially-conscious buyers and receiving a premium price, while furthering farm-to-plate education and awareness. Both producers and consumers are benefiting from this.

Processing

There are three levels of meat inspection: federal, state, and uninspected or custom-slaughter plants. State inspected meat cannot be sold outside of that state, and uninspected meat must be for the owner’s use only and labeled “not for sale.” Federally inspected processing plants that are willing to take a small number of animals, or even keep your meat separate, are very hard to find. You might have to base your marketing on using state-inspected facilities or make arrangements with custom processors. A good option (if your customer wants an entire animal) is to sell the animal live, transport it to the butcher for your client, and have the client pick it up and pay processing fees. Check with your state department of agriculture for your state’s regulations on processing, selling, and on-farm slaughter. Call the USDA Food Safety and Inspection Service hotline at 1-800-535-4555 with any questions about federal regulations. The Niche Meat Processor Assistance Network (www.nichemeat-processing.org) also offers information and resources about meat processing regulations and contacts for locating a processor.

Labeling

There are laws that require your labels to be reviewed by state and federal authorities before they are used in advertising. If your product is a single meat product with no added ingredients, the labeling process should be fairly easy. The USDA Meat and Poultry Labeling Terms can be found at www.fsis.usda.gov/PDF/Meat_and_Poultry_Labeling_Terms.pdf or by calling the USDA Meat and Poultry Hotline, 1-888-674-6854.

Records

No matter how you sell your animals, be sure to obtain a copy of an invoice for your farm records. This is particularly important if you are directly marketing your animals. You should create an invoice that includes the seller’s name, buyer’s name, number of animals (or pounds of meat), price per unit, total price, and date picked up or delivered. Whenever possible, have the buyer sign the invoice.

Value-added products

There are many other products from sheep besides fresh or frozen meat that can provide additional income. The “trimmings” from meat can be used to make sausage, bratwurst, and jerky. Pet foods are also a growing market for lamb producers; you can market organ meat, ground lamb, bones, and other low-end cuts to pet food producers as high-quality, allergen-free ingredients.

Fiber can become a value-added product; you can sell your animals’ wool to make blankets, yarn, or clothing. Some breeds have hides that make beautiful rugs. If you are directly marketing from your farm, you could learn to make these products and sell them on your farm. You can also work with other businesses to get products made from your fiber.

Grazing services

Another enterprise is to offer “grazing services” for forage management. Both parties benefit in this transaction. The producer gets paid to graze his or her animals on another’s property, and the customer gets vegetation managed and fertilized “naturally” by landscaping livestock. Of course, the producer usually provides transportation and a means of containing the animals, closely monitoring that they do not overgraze the land. For more information on grazing services, see *Target Grazing: A Natural Approach to Vegetation Management and Landscape Enhancement* (www.cnr.uidaho.edu/lrx-grazing/Handbook.htm) and *www.livestockforlandscapes.com*.

Breeding stock

If you maintain high-quality, healthy animals, you may have the opportunity to sell breeding stock. These animals will fetch a higher price than animals sold for meat or at a sale barn. Breeding stock can be purebred or crossbred animals. Buyers who are interested in registered animals or show animals are probably more interested in purebred stock, and those who have a commercial flock may want to purchase quality crossbred animals. Keeping detailed production and health records is very important if



Sheep can be used to graze power line right-of-ways. Photo by Susan Schoenian, University of Maryland.

you are selling breeding stock. It may take some time and money to develop a market for your breeding stock. You must sell only healthy, productive animals as breeding stock, because you will have a reputation to uphold.

However you decide to market your animals, always be fair to your customers. A good reputation is the best way to grow your business. For more information on marketing sheep, see www.sheepgoatmarketing.info, www.sheepandgoat.com/market.html, and *Marketing Out of the Mainstream* (www.sheepusa.org/publications).

Organic production

If you are interested in alternative production and marketing methods, you may want to consider organic. “Organic” means, among other things, raising crops or livestock in a way that builds the soil and enhances biodiversity and ecological balance. The term “organic” may not be used except under a production system that meets all the requirements of the National Organic Program Regulations, as defined in 7 CFR Part 205 (see www.ams.usda.gov/AMSV1.0/nop).

Related ATTRA Publications

NCAT's Organic Livestock Workbook

Organic Certification Process

Organic Farm Certification and the National Organic Program

Organic Livestock Documentation Forms

Organic Standards for All Organic Operations

Organic Standards for Livestock Production

Organic System Plans: Livestock Production

Some producers choose to farm organically because they believe in the principles of organic agriculture, that organic systems build the health of soils, plants, animals, and people. Others do so because they want to sell products for a premium price to people who support organic principles and believe organic food is better for their health.

Depending on your production and marketing methods and customers, it may be to your advantage to raise and sell organic lamb or wool. This section highlights what is involved in producing sheep organically, and it will help you decide whether transitioning to organic is worthwhile for your operation.

What are the basic requirements of organic certification? (This is not a complete list.)

- Feed 100% certified organic feed (including pasture).
- Animals must graze on pasture at least 120 days per year, and animals must have a minimum of 30% dry matter intake from grazing pasture during the grazing season.
- Use of most synthetic medicines and/or hormones is prohibited (see the National List for materials and the purposes for which they may be used).
- Maintain organic stock under organic management from at least the last trimester before birth (i.e., ewes must be managed organically for more than 50 days before organic lambs are born).
- Meat must be processed in a certified organic facility and must not be irradiated.

For more information about the requirements for organic livestock production, see ATTRA's *Organic Standards for Livestock Production: Highlights of the USDA's National Organic Program Regulations* (summary of relevant verbatim standards) and NCAT's *Organic Livestock Workbook* (longer workbook format to guide the producer in looking at all components of a production system as they relate to organic standards and practices).

There are also important record-keeping requirements and certification tasks, including the following:

- An organic system (farm) plan approved by a certifying agent
- Up-to-date farm records for at least five years
- Annual inspection of the farm, including records and premises.

For some farms, current production practices are already very close to organic standards. Some farms keep extensive records. But for most, changes will be necessary in both production and record-keeping in order to comply with organic regulations. Will those changes be worth it? Consider the following questions:

- What price do you currently receive for your product?
- Is there local demand for organic products? (If not, you will need to develop a local market or develop one at a distance, and ship your product. Remember, market development costs time, energy, and money.)
- What price could you receive for organic lamb or wool? (Check the Internet for some idea of prices being asked.)
- What do you currently pay for hay or grain to supplement your animals?
- What would you have to pay for organic hay or grain? How dependable is the local supply? Can you offset the increase in the price for organic feed with sales of certified organic animals or products? (Remember, using homegrown feeds, especially pasture, will help greatly.)
- How important is organic certification to your customers? Is it sufficient for them to know you as the producer and understand that you use humane and sustainable practices, or do they need to see verification of organic standards?

Now for the next hurdle — if you are selling meat:

- Is there a certified organic processor in your area? This is necessary if you are selling organic meat.
- If there is not currently an organic processor, can you persuade a local processor to do the paperwork and follow the regulations?
- What extra processing costs will be charged for organic processing?

For information about organic meat processing, see www.extension.org/pages/Certified_organic and www.mosesorganic.org/attachments/broadcaster/livestock14.6meatprocess.html.

If you are selling a live animal:

- Who is your buyer? It's best to have more than one option.
- What is the demand? How many animals can you sell a year, and is it a steady market?

If production costs will be feasible and the market is not a problem, then consider whether you can you raise your animals under organic health management practices.

Organic health care is based on prevention of illness through good management.

- Animals adapted to the environment
- Appropriate vaccinations
- Good nutrition
- Low-stress handling
- Good sanitation
- Access to well-managed pasture, fresh air, and sunshine
- Low stocking rates
- Adequate shelter
- Good preventive care (regular foot trimming, for example)

All the above practices should be followed by producers whether they are certified organic or not, as they are simply good management practices. These practices will prevent many illnesses, assuming there is a closed flock. However, when illnesses do arise, you must

remember that conventional treatments such as antibiotics are not approved for organic production. You will have to find alternative treatments. If those are not effective, then you must use the conventional treatment for humane reasons, and remove the treated animal from organic status. In humid climates, sheep may have serious trouble with internal parasites. Internal parasites can be devastating to the health of the animal, causing loss of productivity and sometimes death. Under the National Organic Program regulations, use of chemical dewormers is restricted for breeding and milking stock (they may not be used on lactating ewes or ewes in the last trimester of pregnancy or on any animals routinely) and is prohibited for organic slaughter stock. If infection is severe, you should use the most effective treatment, including chemical dewormers if necessary. Animals treated with chemical dewormers are no longer certified organic and must be removed from the organic flock. Organic production is probably not a viable option for producers



Using forages helps to keep feed costs lower. Photo by Linda Coffey, NCAT.

who raise sheep in climates that are extremely conducive to internal parasite infections.

See *Managing Internal Parasites in Sheep and Goats* for more information about this important topic. See also the *Organic Livestock Workbook* to get a fuller picture of what is involved in organic livestock production. ATTRA has many other publications that deal with organic certification as well.

For additional information on organic sheep production, see *Transitioning to Organic Sheep or Goat Meat Production* (www.moses-organic.org/attachments/productioninfo/fstransgmeat.html).

Economics

One of the key questions to answer before starting an enterprise is, “Will it be profitable?” The answer is largely dependent on the management and the set of individual circumstances. Many sample budgets have been published, and they are useful in sorting out the various categories of expenses that must be considered.

There are some basic principles to keep in mind that will improve the chances for profit.

- Keep costs low — use forages, feed least-cost rations, maintain healthy animals.
- Pay attention to reproduction — ewes should breed and wean lambs; cull those that don’t.

- Cull animals that aren’t productive — those that don’t breed, don’t wean lambs, or don’t grow as they should.
- Have a consistent market for your product.

The table below illustrates the relationship between cost of production and reproductive performance. Ewe cost is the amount it costs to keep a ewe for a year. This will include feed, veterinary costs, fencing, and any other costs related to keeping your ewes. Lamb crop is the percentage of lambs weaned to ewes exposed to breeding.

Fifteen lambs weaned (marketed) / 10 ewes exposed to ram = 150% lamb crop

So, if it costs you \$50 to keep each ewe, and you had a 150% lamb crop, the lambs would need to bring \$0.33 a pound to break even. Clearly, the chances for profitability are far better if costs are kept low and ewes are productive and lambs survive. Note that market weight for this example is 100 pounds. Lighter lambs must bring higher prices.

The sample budget on the following page is included to assist the prospective producer in planning and in determining feasibility. Remember that costs are subjective and depend greatly on management and location. Your situation will not correspond exactly to anyone else’s.

For more information on economics, including several example budgets and budgets you can adjust to reflect your farm’s costs, see www.sheepandgoat.com/economic.html.

Break-even lamb price in dollars per pound				
Ewe cost (\$/head/yr)	% lamb crop			
	75%	100%	150%	200%
30	.40	.30	.20	.15
40	.53	.40	.27	.20
50	.67	.50	.33	.25
60	.80	.60	.40	.30

Assumed market weight is 100 lbs.

Ewe flock, projected budget for lambs sold in 2010

Production description: Flock of 100 ewes and 3 rams with a 140% lamb crop raised; 22 ewe lambs retained as replacements. Purchase rams at \$300 each.

Estimated income/ewe (lamb crop: 140%)	Spring lambing	Your estimate
Lamb sales: 85 lbs. @ \$100/cwt. x 1.18*	\$100.30	\$
Cull ewe sales: 125 lbs. @ \$40/cwt. x 20%	\$10.30	\$

ESTIMATED TOTAL INCOME/EWE **\$110.30** **\$**

Estimated costs/ewe		
Operating costs		
Pasture (\$20/acre rental rate)	\$20.00	\$
Hay (100 lbs. @ \$70/T.)	\$3.50	\$
Grain (30 lbs. @ 7¢/lb.)	\$2.10	\$
Salt and minerals (10 lbs. @ 20¢/lb.)	\$2.00	\$
Dewormer (4 times/year)	\$2.00	\$
Vaccinations	\$0.42	\$
Insecticides	\$0.24	\$
Marketing and hauling	\$6.00	\$
Utilities and machinery costs	\$6.00	\$
Livestock facility and fence repairs	\$3.00	\$
Professional fees (legal, accounting, etc.)	\$0.50	\$
Miscellaneous	\$2.00	\$
Operating interest (1/2 of operating costs @ 7%)	\$1.67	\$
TOTAL OPERATING COSTS (except labor)	\$49.43	\$
Labor & management (3 hours @ \$11.50/hr.)	\$34.50	\$
TOTAL OPERATING COSTS (including labor)	\$83.93	\$
Ownership costs		
Depreciation and interest on livestock facilities	\$6.00	\$
Interest on ewe and ram	\$8.00	\$
Breeding stock purchases	\$5.00	\$
Insurance and taxes on capital items	\$2.00	\$
TOTAL OWNERSHIP COSTS	\$21.00	\$

ESTIMATED TOTAL COSTS/EWE **\$104.93** **\$**

Income over operating costs	\$26.37	\$
Income over total costs	\$5.37	\$

Budget prepared by Ron Plain, Extension Economist, University of Missouri-Columbia.

*100 ewes x 140% lamb crop = 140 lambs; 140 lambs - 22 lambs retained as replacements = 118 lambs to sell.

Conclusion

Sheep are generally easy to incorporate into a farming operation. They are small, relatively inexpensive, and integrate well with other livestock. Sheep do not share internal parasites with other livestock (except goats) and prefer vegetation different from what cattle, goats, and horses typically eat. Sheep are efficient because ewes can wean two or more offspring that weigh as much as or more than the ewe.

You must be careful when selecting sheep. Never buy breeding stock from a sale barn, and only buy healthy animals. Choose a breed that is best for your farm. Keep animals healthy by feeding them properly, giving them access to clean pasture, trimming their hooves as necessary, properly vaccinating, not overcrowding them, and de-worming only when necessary. Properly contain your animals with appropriate fencing, and protect them by providing an effective livestock guardian animal. Keep extensive records of vaccinations, de-worming, and all other medical treatments. To increase efficiency, cull animals that repeatedly have problems. This will avoid spread of disease, save money, and build a stronger, healthier flock.

There are many marketing options available. Sheep can be marketed at a sale barn, in pooled sales, or directly from your farm. Choose the market that is right for you and your operation. You can diversify your sales by offering breeding stock, grazing services, or value-added products. Always be honest and informed; if customers do not trust you, they will not return. You might consider organic production if you have a conducive environment. Remember to familiarize yourself with the regulations, make a plan, and speak to an expert when you begin any enterprise, particularly a certified organic one.

Never take the leap of beginning a business without knowing the economics. Create a business plan. Your venture should be realistically profitable on paper before you buy your first sheep. Keep records and analyze your budget regularly. Keep costs low by using forages and maintaining healthy animals. Have a plan for emergencies, and always be prepared to change your plan as your circumstances change.

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Further resources

For a more extensive list of resources, see ATTRA's *Small Ruminant Resource List*, www.attra.org/attra-pub/small_ruminant_resources.html

ATTRA Publications

An Illustrated Guide to Sheep and Goat Production
This basic and heavily illustrated introduction to sheep and

goat production discusses animal selection, feeding, breeding and young stock, equipment and handling, and marketing.

Small Ruminant Sustainability Checksheet

This checksheet is designed to stimulate critical thinking when evaluating a farm that produces sheep or goats. The sustainability of a farm depends on many factors involving farm management, use of resources, and quality of life. The questions in the checksheet are intended to stimulate awareness rather than to rate management practices. Use this guide to define areas in your farm management that might be improved, as well as to identify areas of strength.

Predator Control for Sustainable and Organic Livestock Production

This publication focuses primarily on the control of coyotes and dogs, which are the main causes of livestock lost to predation, through management practices such as fencing and secure areas, and the use of guard animals

Managing Internal Parasites in Sheep and Goats

This publication discusses new techniques to manage parasites and to prolong the efficacy of dewormers. New management tools that remain under study are also discussed. A list of resources follows the narrative.

Tools for Managing Internal Parasites in Small Ruminants: Copper Wire Particles

The publication contains information on how to make boluses of copper wire oxide particles, and reports results of studies on the effectiveness of this treatment.

Tools for Managing Internal Parasites in Small Ruminants: Sericea Lespedeza

This publication discusses tools that can be used to manage internal parasites of sheep and goats that are becoming resistant to conventional dewormers. One such tool is the forage sericea lespedeza. The publication discusses how it can be used and presents the results of research on how it reduces parasites in small ruminants.

Ruminant Nutrition for Graziers

This publication provides managers with tools and references for considering biological and climatological variables in making decisions that ensure the ecological and economic viability of a grass-based ruminant livestock operation.

Multispecies Grazing

Brief overview of why multispecies grazing is beneficial, as well as considerations for management.

Books

Storey's Guide to Raising Sheep, by Paula Simmons and Carol Ekarius. 4th Edition. 2009. Storey Publishing, LLC., Pownal, VT. 400 p.

This book is a very useful resource, covering many aspects of raising and marketing sheep and their products. It is enjoyable to read and helpful to beginners and experienced producers alike.

More Sheep, More Grass, More Money, by Peter Schroedter. 1997. Ramshead Publishing Ltd. Moosehorn, Manitoba. p.112

Personal experiences of the author, emphasizing the need to make a profit with the sheep enterprise and giving examples of how to cut costs and increase profits. Emphasis on grazing management. Very practical.

Storey's Barn Guide to Sheep. Storey Publishing. 2006. Storey Publishing, LLC. Pownal, VT. 96 p.

This spiral-bound book with large, heavy-duty pages is designed to accompany the farmer to the barn and is complete with step-by-step guides with several straightforward illustrations.

Marketing Out of the Mainstream: A Producer's Guide to Direct Marketing of Lamb and Wool, by Tamra Kirkpatrick and James Bell. Sheep Industry Development Program. 57 p.

Websites

Maryland Small Ruminant Page
www.sheepandgoat.com

American Sheep Industry Association
www.sheepusa.org

National Sheep Improvement Program
www.nsip.org

Sheep and Goat Marketing Program
www.sheepgoatmarketing.info

Southern Consortium for Small Ruminant Parasite Control
www.scsrpc.org

Lamb Eaters Connection
www.lambeatersconnection.com

Sheep: Sustainable and Organic Production

By Margo Hale, Linda Coffey
NCAT Program Specialists

Ann Bartlett, Chelsey Ahrens
NCAT Interns

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Paul Williams, Editor
Adrienne Herren, Production

This publication is available on the Web at:

www.attra.ncat.org/attra-pub/sheep.html

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California Grazing Academy
Stocking Rate & Carrying Capacity



David W. Pratt
U.C.C.E. Farm Advisor

The **CARRYING CAPACITY** is the number of animals that a paddock or cell can accommodate without overgrazing. Simply put, the carrying capacity is how much grass you have. **STOCKING RATE** is the feed demand. It is the amount of forage your stock are going to eat. Another way of thinking about this is:

Carrying capacity is what nature gives us.
Stocking rate is what we take from her.

The first principle of controlled grazing is:

FLUCTUATE STOCKING RATE TO MATCH CARRYING CAPACITY

If we knew how much grass our paddocks would produce, or if we started the year with a fixed amount of feed it would be a relatively simple process to ration it out over the course of the year. But we don't know what production will be until the season is over. Forage production, and therefore carrying capacity, varies greatly from month to month and year to year. It depends on the weather and our grazing management.

Adjusting stocking rate as carrying capacity changes
is fundamental to good grazing management.

There are really two concerns here: 1) fluctuating the stocking rate to reflect seasonal changes in carrying capacity; and 2) adjusting stocking rate to match annual changes in carrying capacity.

1. ADJUSTING THE STOCKING RATE SEASONALLY

We may not be able to precisely predict how much grass will grow, but in most environments we can predict when it will grow. For example, we know that winter growth on California's foothill rangelands is slow. The green grass is high quality but there simply isn't much there. In spring growth is fast and there is a lot of high quality grass. In summer and early autumn there is very little growth. We generally expect feed quantity and quality to decline through this period. In controlled grazing, graziers must anticipate and plan for the spring "boom" and autumn "bust" of these foothill rangelands.

Just as carrying capacity changes with the seasons, nature is also constantly adjusting stocking rates. We all know that when cows calve, lactate, get bred and wean their calves their feed requirements change. For example, a cow in heavy lactation requires about 60% more energy than a dry cow. The stocking rate of a one acre paddock grazed for one day with 100 lactating cows is 60% higher than that same paddock grazed for one day by 100 dry cows. *By matching our animals' production cycle to our pasture's annual production cycle we can synchronize stocking rate with carrying capacity.*

2. ANNUAL STOCKING RATE ADJUSTMENTS

Stocking rate can be adjusted down in poor feed years by weaning calves or lambs early, or culling more heavily than usual. The earlier you make a decision to destock, the less severely you'll need to cull. (Every mouthful an animal doesn't eat today is a mouthful left for another animal tomorrow).

In good feed years stocking rate can be increased by culling lightly, retaining more replacements, carrying calves over as stockers or contracting to graze more stock.

The enterprise mix should reflect the drought risk. Ranches in environments where drought is common, should probably be stocked conservatively with cows. Surplus forage in good years can be used by stockers. Cow/calf producers in drought prone environments facing destocking decisions every few years should reevaluate their enterprise mix.

There are several methods for estimating stocking rate. One that we feel is particularly useful is described in *Livestock & Range Report No. 943 "Estimating Stocking Rate."* But keep in mind that the numbers you calculate are only estimates. It is important to monitor actual production, utilization and livestock performance during the season. Graziers must always be looking ahead at the next paddocks to be grazed to make sure there is enough feed. If there isn't enough feed you are either overstocked, your graze periods are too long, or you are not allowing enough recovery time regardless of what your estimates told you.

DEFINITIONS

CARRYING CAPACITY: The number of animals that a paddock or cell can accommodate without overgrazing.

STOCKING RATE: The feed demand of livestock grazed. The stocking rate can be measured in "stock days" grazed in a paddock.

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California Grazing Academy Estimating Carrying Capacity



David W. Pratt, U.C.C.E. Farm Advisor

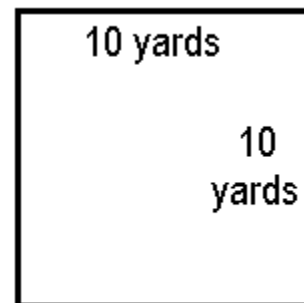
LIVESTOCK & RANGE REPORT NO. 943 SUMMER 1994

Napa & Solano Counties U.C.C.E., Livestock/Range Management Program

Several people use and teach the method described in this paper for estimating carrying capacity. I learned it from Dr. Stan Parsons at his *Ranching For Profit School*. It is best applied near the end of the growing season when little additional growth is expected.

PROCEDURE:

1. Pace off an area you think has enough forage to feed an animal for one day. Try to keep your paces one yard long. (This works best with four people, one to stand at each of the paced area. If you don't have enough people you can tap stakes in at the corners.)
2. If the area looks too small, everyone should take a step back. If the area is too big take a step in.
3. Multiply the length of the area (in yards) by the width. This gives you the area required by one animal for one day in square yards.
4. Divide the square yards per acre (4840) by the square yards required per animal per day. The result is the number of stock one acre can support for one day (Stock Days per Acre, SDA).



10 x 10 = 100 Square Yards

4840 Sq.Yards/Acre ÷ 100 Sq.Yards/Animal/Day = 48.4 SDA

5. Multiply SDA by the number of acres in the paddock. The result is stock days per paddock. For example, if the square on the previous page is representative of a 12 acre paddock, then:

48.4 SDA x 12 acres = 580 SD in the paddock

6. Since the quantity of forage produced may vary within each paddock, you may have to average several estimates to come up with a reliable assessment of the SD per paddock.

By adding the stock days for each paddock on the ranch you can determine the total days of grazing available on the property.

TEST YOUR ESTIMATE

You'll be surprised at how quickly you can accurately evaluate the carrying capacity of pastures. However, your estimates are likely to be off a bit when you try this for the first time. The accuracy of your estimate can be tested simply by putting a stock in a small paddock to graze.

For example, we estimated that there are 580 stock days of feed available in our 12 acre paddock. If our herd consists of 200 head, there should be almost 3 days of grazing available in the paddock:

$$580 \text{ SD} \div 200 \text{ stock} = 2.9 \text{ Days}$$

If we check the paddock at the end of the second day and find we are out of feed, then our estimate was too high (we need to make our square larger next time). If we find there is more feed left than we anticipated at the end of the planned three day graze period, then our estimate was too low (we should make our square smaller next time).

You may want to check your estimates on a small area using some temporary portable electric fencing. With experience, simply monitoring the severity of grazing in the paddocks during the graze period is sufficient.

DEFINITIONS

STOCK DAY (SD): The amount of forage required to support one animal for one day.

STOCK DAYS PER ACRE (SDA): The number of animals that can be supported on one acre for one day.

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California Grazing Academy
Principles of Controlled Grazing



David W. Pratt, U.C.C.E. Farm Advisor

LIVESTOCK & RANGE REPORT NO. 932 SPRING, 1993

Napa & Solano Counties U.C.C.E., Livestock/Range Management Program

GRASS FARMING

Ranching is really the business of converting sunlight energy into forage and forage into harvestable livestock products in a sustainable manner. From this perspective we see that those of us in the livestock business are also in the grass business. Allan Nation, editor of the Stockman Grass Farmer would say we are "grass farmers" and our livestock are the four legged combines with which we harvest our crop.

Most of us have considered the livestock business, not the grass business, as our primary occupation. As a result, our focus has been on the animal. We have a relatively poor understanding of how our crop grows and responds to grazing. An understanding of this relationship is fundamental to successful grass farming.

GREEN LEAVES CAPTURE SUNLIGHT

Sustainable production in ranching starts with using plants to capture sunlight energy. When sunlight falls on bare soil, rocks, or anything but growing plants, its energy cannot be harvested.

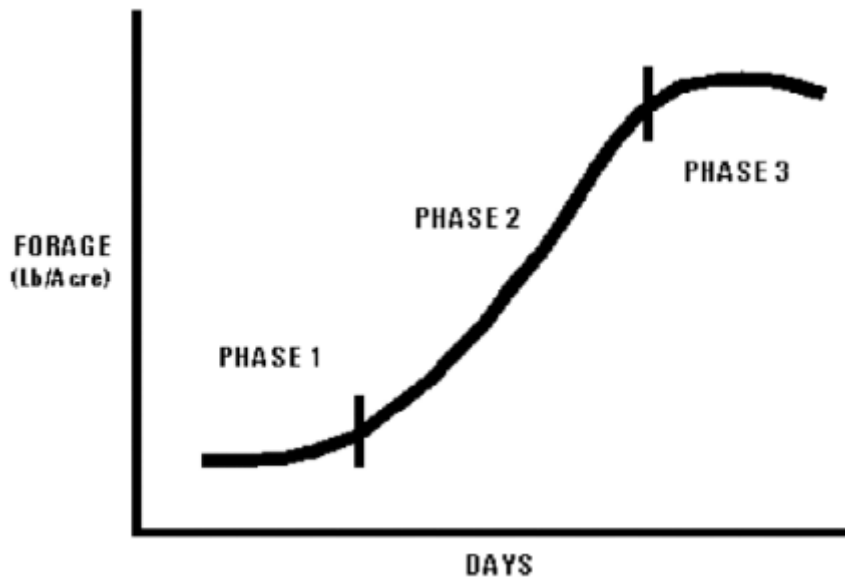
Principle: Maintain 100% green plant cover in pastures for as long as possible.

THE "S" SHAPED CURVE

The efficiency with which plants convert the sun's energy into green leaves and the ability of animals to harvest and use energy from those leaves depends on the phase of growth of the plants.

After grazing, plants go through three phases of growth that form an "S" shaped curve (figure 1). **Phase I** occurs after plants have been severely grazed. After grazing, fewer leaves are left to intercept sunlight and plants require more energy for growth than they are able to produce through photosynthesis. So, to compensate, energy is mobilized from the roots. The roots become smaller and weaker as energy is used to grow new leaves.

FIGURE 1. PLANT GROWTH AFTER GRAZING (THE 'S' SHAPED CURVE)



Plant growth during phase I is very slow but the leaves are extremely palatable and nutritious.

Remember phase I - high quality but low quantity.

When regrowth reaches one fourth to one third of the plant's mature size, enough energy is captured through photosynthesis to support growth and begin replenishing the roots. This is **phase II**. It is the period of most rapid growth. During phase II, leaves contain sufficient protein and energy to meet the nutritional needs of most livestock.

Remember phase II - high quality and high quantity.

As plants continue to grow, leaves become more and more shaded. Lower leaves die and decompose. Leaves use more energy for respiration than they can produce through photosynthesis. This is **phase III**. Phase III material is stemmy and fibrous. Nutrient content, palatability, and digestibility of leaves in phase III material is poor.

Remember phase III - low quality but high quantity.

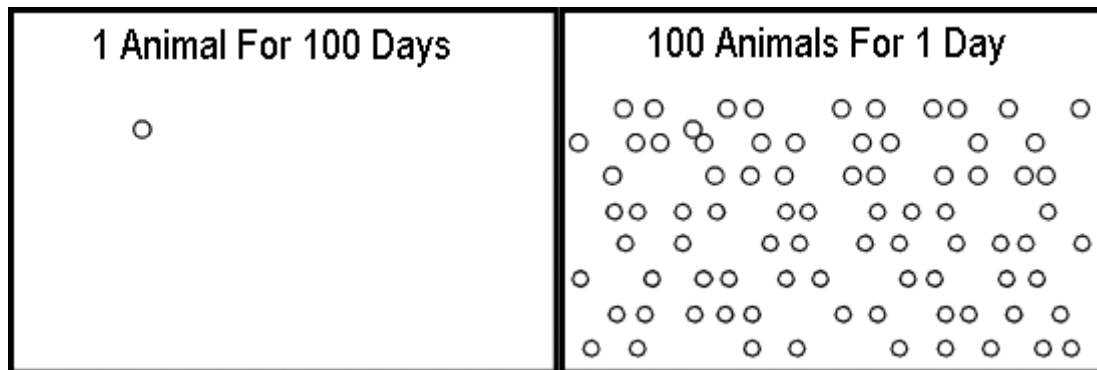
Principle: Adjust grazing and rest periods to keep plants in Phase II, the most rapid period of growth.

Do not graze plants so short that they enter phase I. Phase I regrowth is very slow and will reduce total productivity. Do not allow plants to enter phase III. In phase III, shading and senescence begin to detract from efficiency of photosynthesis. **The harvest of energy from your pastures will be maximized by keeping plants in phase II.**

OVERGRAZING IS A FUNCTION OF TIME

Which would cause more overgrazing: one animal grazing a one acre paddock for 100 days, or 100 animals grazing that same paddock for one day? (figure 2) The stocking rate of both paddocks would be identical: 100 Animal Days per acre. But the effect on the paddocks would be much different.

FIGURE 2. VARYING TIME & NUMBERS WITH CONSTANT STOCKING RATE



In the first case, the animal would keep returning to areas previously grazed because the new growth would be more palatable and nutritious than the older growth of ungrazed plants. In the second case, the animals would probably graze everything in sight but would not have the chance to regrazed plants. So, which would cause more overgrazing? To answer we must first know what overgrazing is.

Overgrazing is grazing a plant before it has recovered from the previous grazing.

Overgrazing occurs in two ways: leaving stock in a pasture too long or bringing them back too soon.

It is important to make a distinction between severe grazing and overgrazing. Most people use these terms interchangeably. I define them differently. Severe grazing means removing a lot of the plant, but it does not tell you how long a plant was exposed to grazing. Overgrazing means that a plant was regrazed before it recovered from a previous grazing. By this definition, a severely grazed plant has not necessarily been overgrazed ... but neither extremely severe grazing or overgrazing is good.

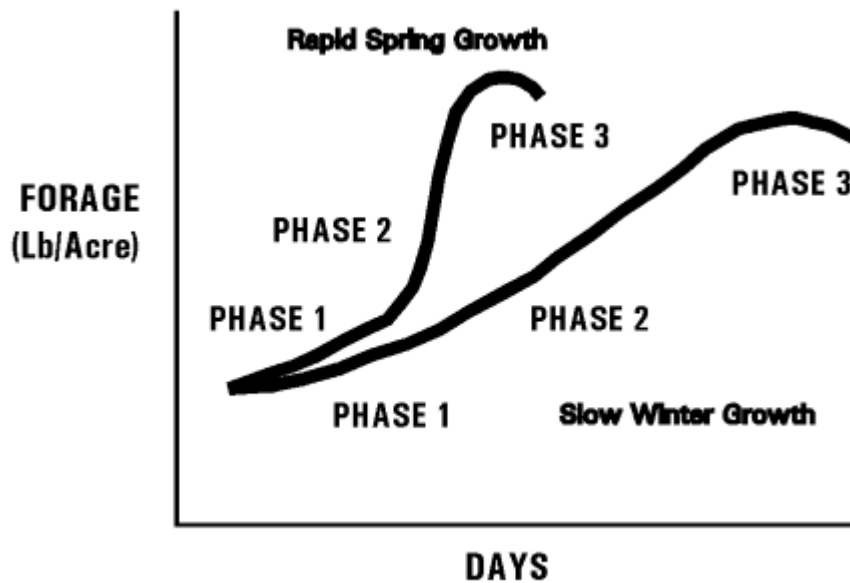
Now, let's relate this back to the two pastures. The first case (one animal for 100 days) resulted in regrazing of plants...overgrazing. There would also be many plants that were completely ungrazed. There would be plants in both phase I and III of the S shaped growth curve. Neither overgrazing or undergrazing is desirable.

The second case (100 animals for one day) may have resulted in severe grazing, but plants would not be grazed while they were recovering ... there would be no overgrazing.

PASTURE GROWTH RATES CHANGE

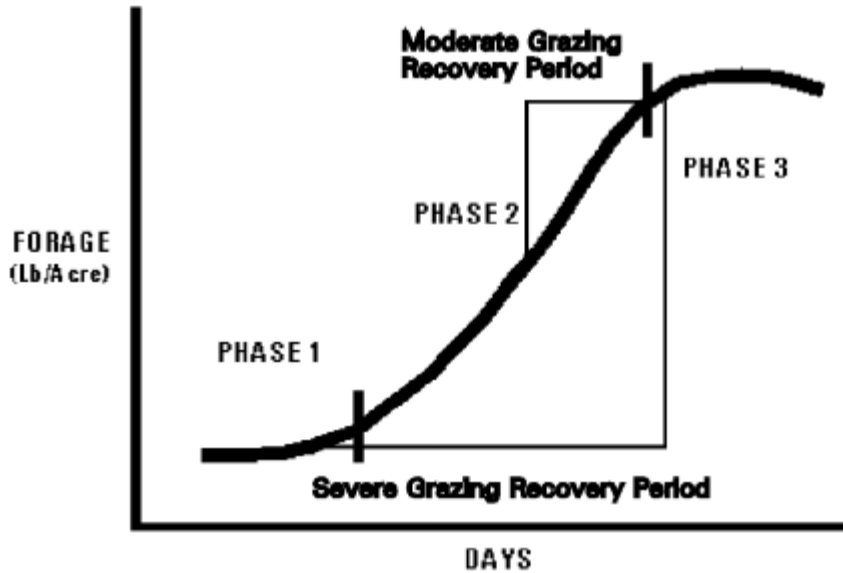
The rate of plant recovery depends on the growing conditions. Plants recover much more slowly during our cool winters than during our warm wet springs (figure 3).

FIGURE 3. PLANT GROWTH AFTER GRAZING DURING RAPID GROWTH & SLOW GROWTH



The growth rate also depends on the severity of grazing (figure 4). When plants are severely grazed their recovery is slow. When grazing is less severe, the recovery is relatively rapid. Increasing grazing severity by 25% may increase recovery time and decrease the productivity of the pasture by 100%!

FIGURE 4. EFFECT OF LIGHT & SEVERE GRAZING ON PLANT RECOVERY



Producers should avoid severe grazing and set rest periods to provide adequate time for plant recovery. During slow growth and dormant periods, rest periods should be long (60 to 120 days). During periods of rapid growth, rest periods should be shortened (30 to 45 days).

Principle: Adjust rest periods to reflect rate of plant growth. Slow growth = longer rest. Fast growth = shorter rest.

COWS ARE GOURMETS

Time is also a critical factor from the animal's standpoint. The forage consumed and the quality of the diet changes during an animal's stay in the pasture.

Cows are gourmets. They graze selectively, eating the best plants and plant parts first, avoiding coarser, less palatable, less nutritious feed. Stock eat most on the first day of grazing (figure 5). As the days pass, the forage gets older and less digestible, and stock spoil more and more grass through trampling and dung and urine contamination, so they eat less.

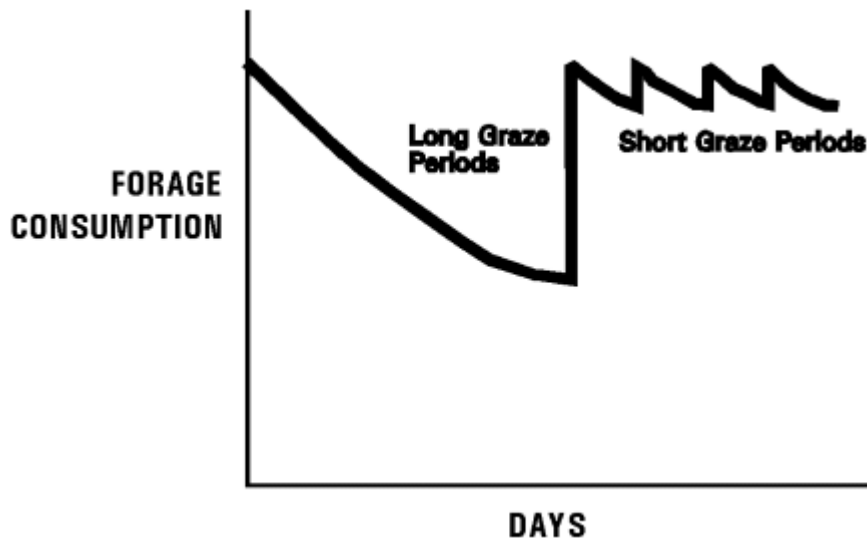
In heavily stocked continuously grazed pastures, regrowth will be grazed as soon as it's available. The phase 1 regrowth is highly nutritious, but there is generally not enough of it to support high levels of animal production.

Lightly stocked continuously grazed pastures consist of plants in phase I and phase III. If animals are forced to eat phase III material, which passes through their gut very slowly, their daily intake will drop because they simply can't fit any more feed in their rumen. The result is poor animal performance.

In contrast, imagine a situation where animals are frequently moved to fresh feed. Forage consumption would remain high. The quality of the diet would also remain high.

Principle: Make graze periods as short as possible while maintaining adequate rest periods

FIGURE 5. EFFECT OF GRAZE PERIOD LENGTH ON FORAGE CONSUMPTION



SUMMER ROTATION ON ANNUAL RANGES

During the dry season annual plants will not be damaged by continuous grazing, after all, they are already dead. But, there are still benefits of controlling the length of the graze and rest periods. They include more total pasture production, more uniform utilization, less forage waste, improved and more uniform nutrition for livestock and better control of the amount of residue left to maintain healthy water and nutrient cycles.

Consider this: we've observed a dramatic increase in the number and vigor of desirable perennial grasses under this type of management. Do you think we'd be seeing the perennials if we grazed continuously through the summer? Perennials can only become established if the land is managed as though they are already present.

STOCK DENSITY

Stock density is the number of animals in a particular area at any moment in time. It is usually expressed in terms of number of head per acre:

$$\text{STOCK DENSITY} = \text{HEAD} \div \text{ACRE}$$

For example if 50 steers are grazing a 10 acre paddock the stock density is 5 head/acre:

$$\text{STOCK DENSITY} = 50 \text{ HEAD} \div 10 \text{ ACRES} = 5 \text{ head / acre}$$

In his book Holistic Resource Management, Allan Savory says, "Low density, not overgrazing or overstocking, should bear the blame for many serious range and production problems, including trailing, successional shifts toward brush and weeds, pest outbreaks, poor animal performance, and high supplemental feed costs...". To understand why, let's take another look at the two one acre paddocks described earlier (Figure 2).

The two paddocks had identical stocking rates (100 animal days per acre), but they were grazed for different periods of time and the stock densities were drastically different.

In the first paddock, with one animal grazing for 100 days (stock density 1 animal/acre), utilization was uneven, with some plants overgrazed and others undergrazed. In the other paddock, where one hundred animals grazed for one day (stock density 100 animals/acre), utilization was more uniform and there was no overgrazing. Shortening the graze period reduced overgrazing, but it was the increase in stock density that resulted in more even utilization.

Overgrazing is a function of time.

Uniformity of utilization is a function of stock density.

Pastures with low stock density usually appear "patchy" with some patches grazed very short and other patches consisting of rank, "wolfy," phase III vegetation. Some ranchers mow pastures to keep vegetation uniform and palatable. Others use fire to remove old, stemmy, ungrazed material. What they usually really need is higher stock density.

High stock density increases the uniformity of utilization and maintains forage in a more palatable, nutritious, digestible condition.

Stock density increases as the number of animals in a paddock increase or as paddock size decreases.

Principle: Use the highest stock density possible.

Twenty head per acre is the minimum stock density needed to uniformly graze irrigated pasture. Higher is better. Stock densities of over 50 cattle per acre are not uncommon on well managed irrigated pastures. Two head per acre is a reasonable target on more remote ranges. Again, higher is better.

HERD EFFECT

If you haven't already seen the movie *Dances With Wolves*, get out the popcorn and rent it tonight. When it gets to the scene where they are tracking the buffalo, stop the tape and reread this section.

After the buffalo stampeded through, the range literally looked plowed. This is a natural phenomena called herd effect. When animals are spread out and calm, their hooves tend to compact the soil. When they are concentrated and excited, they tend to knock down old standing vegetation and break up the soil.

Herd effect will not happen just by increasing stock density. To achieve this effect it is usually necessary to stimulate animals in some way. It can be done by herding through or feeding on the area where you want this impact.

In addition, would it be easier to achieve herd effect with a group of 2 cows on 20 acres or 200 cows on 2000 acres? You cannot achieve herd effect with small groups.

Principle: Use the largest herd consistent with good animal husbandry practices.

Herds of up to 800 cows or 2500 stockers can be run without behavior problems. Added benefits of combining herds will be to increase the number of paddocks in the rotation and increase stock density.

PADDOCKS

Adequate time control and stock density can be achieved on many ranches with 16 paddocks. However, the "right" number of paddocks will vary and depends on the length of the required rest and desired graze periods and the stock density needed to achieve uniform utilization.

Most ranchers can begin implementing these basic principles without building new fences. By combining herds and closing some gates, there may already be enough fencing to control graze and rest periods and increase herd size and stock density. When fencing is required, consider minimal electric fence designs. Material costs for effective high tensile electric fences usually vary between \$500-\$1000 on rangelands.

IS CONTROLLED GRAZING RIGHT FOR YOU?

Controlled grazing will help you maximize the sustainable production of high quality forage and animal products from the land. It can be practiced on irrigated pasture or dry rangelands.

But controlled grazing isn't right for everyone. If none of your cows got bred because your bulls were all infertile, you'd better spend your money on new, fertile bulls before you spend it on new fences. But if the "weak link" in your operation is converting sunlight energy into forage, or converting the forage you already have into animal products, then controlled grazing can improve profitability.

It would be nice if I could give you a recipe for controlled grazing that showed the number of paddocks you should have, the number of animals you should graze and the length of rest and graze periods. But there is no controlled grazing cookbook. What works on one ranch may not be suited to another. If you would like to discuss the application of these principles to your operation, please call. There are several local ranchers starting to implement controlled grazing programs. Working together we can all be more successful.

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Grazing management for healthy soils

by Christine Jones

Section 1.01 Summary

The roots of grasses form a mirror image of the tops. This relationship provides a very useful guide to the health and productivity of grasslands. In general terms, the removal of leaf area through grazing results in root pruning, while resting from grazing enables root strengthening. Continuous root pruning (as happens to the most palatable components of a grassland when the grazing process is not controlled) reduces root biomass, slows nutrient cycling, exhausts plant reserves and ultimately causes plant death. However, grasses also degenerate if overrested. The grazing process therefore needs to be carefully managed, using intermittent grazing and resting to stimulate the growth of new leaves and to provide pruned roots as organic matter for soil biota.

Christine Jones



Fig. 1. A grass plant's roots are about the same size as its top.

Section 1.02 Introduction

Healthy soils are the cornerstone of all agricultural productivity. The way we manage plants for healthy soils, through control of the grazing process, is the focus of this paper. An examination of excavated plant roots from many sites throughout temperate Australia, plus insights gained while working with landholders on the biological monitoring of their pastures, have made it abundantly clear that good grazing management requires:

1. understanding how to use grazing to stimulate grasses to grow vigorously and develop healthy root systems
2. using the grazing process to feed livestock AND soil biota
3. maintaining 100% soil cover (plants, litter) 100% of the time (NO exceptions)
4. rekindling natural soil forming processes
5. providing adequate rest from grazing without overresting

All five criteria are equally important. Conservatively stocked properties may appear healthy at a casual glance and are usually in better condition than land heavily overstocked for long periods. However, on closer inspection, it can be seen that damage is still occurring, albeit at a slower rate. Any land which is continually exposed to grazing animals will fail to meet the five criteria listed above. There are many indicators. Patch grazing, bare ground between plants, unhealthy root systems, little evidence of biological activity in soils, nutrient transfer to stock camps, low litter levels, weed invasion, tracking, damage to riparian zones, reduced moisture-holding capacity and fluctuations in water table levels affecting streamflow, spring flow and the incidence of dryland salinity. Continuous grazing represents zero grazing management. Graziers who do not proactively manage the grazing process unwittingly place themselves in an ongoing confrontation with nature.

Section 1.03 Grasslands and grazers

The resource degradation associated with unmanaged grazing often leads to well-intentioned requests for permanent "grazing exclusion". However, grasslands and grazers have co-evolved over millions of years, and grasslands NEED grazers, be they kangaroos, elephants, termites or sheep, to facilitate energy flow and the recycling of nutrients. In medium to low rainfall areas, grasses which are not grazed become senescent and cease to grow productively (McNaughton 1979). If all herbivores are excluded, the health of the grassland declines over time.

The use of fire as an alternative method of biomass removal and growth stimulation may appear attractive, but results in atmospheric pollution, the loss of many nutrients which would be recycled in the grazing process, loss of surface litter, and, if used frequently, bare ground with a capped soil surface which inhibits the infiltration of rainfall (Savory 1988). Landholders may occasionally have valid reasons to use fire, such as woody weed control, or the enhancement of fire-dependent species. However, in view of the risks, fire is a tool which should be used cautiously and infrequently.

Managed grazing is arguably the only natural process by which grasslands can be "improved" on a sustainable basis. Unmanaged grazing, or complete exclusion from grazing, will inexorably (whether it be quickly or slowly) lead to desertification in all but the high rainfall areas (Savory 1988). To achieve healthy grasslands in medium to low rainfall areas, stock need to be bunched into large mobs and moved frequently (Savory 1988). Grazing cells provide a convenient tool for stock control. In extensive areas with few fences, stock can be herded, as is now the practice on many large tracts of public land in the United States and Canada. However, there is far more to grazing management than putting stock together and manipulating the graze and rest periods. High density short duration grazing *per se* can also lead to resource degradation in the absence of ecological guidelines which ensure that all five criteria previously listed are satisfied. When all five criteria are met, grazing acts as a rejuvenating process.

Section 1.04 The living soil

Our soils are the basis of all productivity, but what makes a healthy soil? To be truly healthy and working FOR you, rather than having to be "propped up" with costly inputs, soil needs to be living. Only the biological activity which accompanies plants can turn mineral soil (i.e. a collection of weathered rock minerals) into living soil. Maintaining permanent groundcover and using the grazing process to prune roots to feed soil organisms (soil biota), is of fundamental importance for the regeneration of grasslands.

An enormous number and variety of organisms live in healthy soils, and perform many functions. Large soil invertebrates, such as earthworms and dung beetles, are easy to see and more familiar to most of us than the microscopic components. They assist in the decomposition of plant litter and animal manure by making it more accessible to soil microbes. In turn, the activities of microbes (e.g. soil fungi and bacteria) can release up to twice the amount of plant nutrients (such as phosphorus) than are available from applied fertiliser.

How can we increase biological activity in soils? Like us, soil organisms cannot survive without water, food and shelter. That is, they require suitable habitat and a reliable food source. These requirements are met by organic matter in, and on the surface of, the soil.

Surface litter reduces temperature extremes (both hot and cold, like a roof on your house), and aids the infiltration of rainfall. It also reduces evaporation, so that the net effect of keeping soil permanently covered is that it stays moister for longer. Plant roots in the soil, both living and dead, provide substrate (food) for soil organisms, in a form which is most available when conditions are warm and moist. This is fortunate, because the nutrient cycling activities of soil organisms in turn make nutrients available to plants when the plants most need them, at a rate at which they can be utilised. This is one of the multiple benefits of working WITH nature. These nutrients would otherwise be leached below the root zone or adsorbed (fixed) onto soil particles in an unavailable form (Singer and Munns 1992).

Section 1.05 Root pruning

Controlled grazing is the **management of the relationship between animals, plants and the soil**. When undertaken in such a way as to provide organic matter in the form needed for healthy, living soils, controlled grazing can regenerate grasslands and improve livestock production simultaneously.

Fig. 2. The biomass of the roots and the tops of grasses are roughly equal, forming a mirror image. Short grasses (left) have small root systems.



Christine Jones

In grasslands, grass plants and their litter form the primary interface between animals and the soil. The biomass of the tops and the roots of grasses are roughly equal, forming a mirror image (Fig. 2). The energy for root growth and metabolism can only come from sunlight captured by the plant top during photosynthesis. A small plant top cannot possibly support a large root system. Short grasses have short roots (Fig. 2, left). Vigorous grasses have dense, multi-branched roots (Fig. 2, right).

Deep, fibrous root systems provide a multiplicity of benefits including soil aeration, erosion control, enhanced nutrient cycling, soil building, increased water-holding capacity and reduced groundwater recharge. They also provide habitat and substrate for soil biota such as free-living nitrogen-fixing bacteria.

Fig. 3. Continual grazing pressure on the most palatable grasses provides a competitive advantage to the less palatable grasses for water and nutrients

Christine Jones



Grass plants and their litter form the primary interface between animals and the soil. When livestock are left in the same paddock for long periods of time they place continual grazing pressure on the most palatable grasses and these are kept short (Fig. 3). The compromised root system of these overgrazed plants cannot function effectively. Nutrient availability may be reduced 80-90%, creating an ongoing requirement for fertiliser application. Short root systems also render plants extremely vulnerable during droughts.

Fig. 4. When desirable grasses are rested (right) and then rapidly defoliated through pulsed grazing (such as cell grazing), the roots are pruned within a few hours to equalise the biomass (left). This root pruning effect is regenerative rather than degenerative.

Christine Jones



If desirable grasses are rested from continuous grazing (Fig. 4, right) and then defoliated in a single grazing event (such as in cell or pulsed grazing), a large proportion of roots cease respiring and die within a few hours of the removal of the leaves, in order to equalise the biomass (Richards 1993). The root pruning effect (Fig. 4, left) is regenerative rather than degenerative. These "pruned roots" provide extremely valuable organic matter which improves the physical, chemical and biological attributes of the soil.

It is fundamentally important that grasses be rested prior to the next graze, to rebuild new root systems (Earl 1997). Leaf regrowth can begin within hours of grazing, provided conditions are favourable (Richards 1993). However, re-grazing at this sensitive stage will severely deplete plant reserves, resulting in either plant death or the formation of a steady-state type of equilibrium, where both tops and roots remain restricted in size, such as is found in mown turf and continuously grazed grassland (Richards 1993).

During the graze period (which is most commonly one, two or three days) approximately 20% of the available forage should be trampled to form surface litter and approximately 20% left standing (i.e. around 60% utilised for animal consumption). The percentages vary with

circumstances but the importance of forming surface litter cannot be overemphasised. Finally, if the grassland is to be productive, it must not be overrested. Senescent plants are relatively nutrient poor and have low digestibility and inactive root systems. Overgrown grasses, in particular, can inhibit the growth of other herbaceous grassland species such as forbs, which contribute to both biodiversity and livestock production. For these reasons, the grasses which are desirable from an animal production perspective need to be grazed intermittently. Remember however, that a low percentage of relatively unpalatable, ungrazed bunch grasses is beneficial. These reduce wind-speed, improve humidity at ground level and provide habitat for small living things above and below ground. The result is higher overall productivity than can be obtained from short, uniform pastures.

Section 1.06 Competitive interactions between species

What about the grassland components we don't want? The plants we call weeds? It is often said that for as long as we spray weeds there will be weeds to spray. This truism applies equally to the ploughing, burning or deliberate application of grazing pressure to unwanted plants. Attempting to manipulate a limited number of species, be they considered desirable or undesirable, with little consideration for the dynamics of the entire plant and animal community, can lead only to a deterioration in ecosystem processes and landscape function (Savory 1988).

When the grazing process is not managed, stock continually select the most palatable pasture components (Earl and Jones 1996). As already mentioned, if these plants are overgrazed they will have short roots. This prevents them from competing effectively with relatively unpalatable, ungrazed weeds, which will have deeper root systems (Fig. 5A). In this situation, the ungrazed weeds have an obvious advantage in obtaining water and nutrients, particularly during droughts. If the "softer" grasses are overgrazed to the point where they die, it is highly likely that the less palatable species, which have had the opportunity to seed, will take their place.

Christine Jones

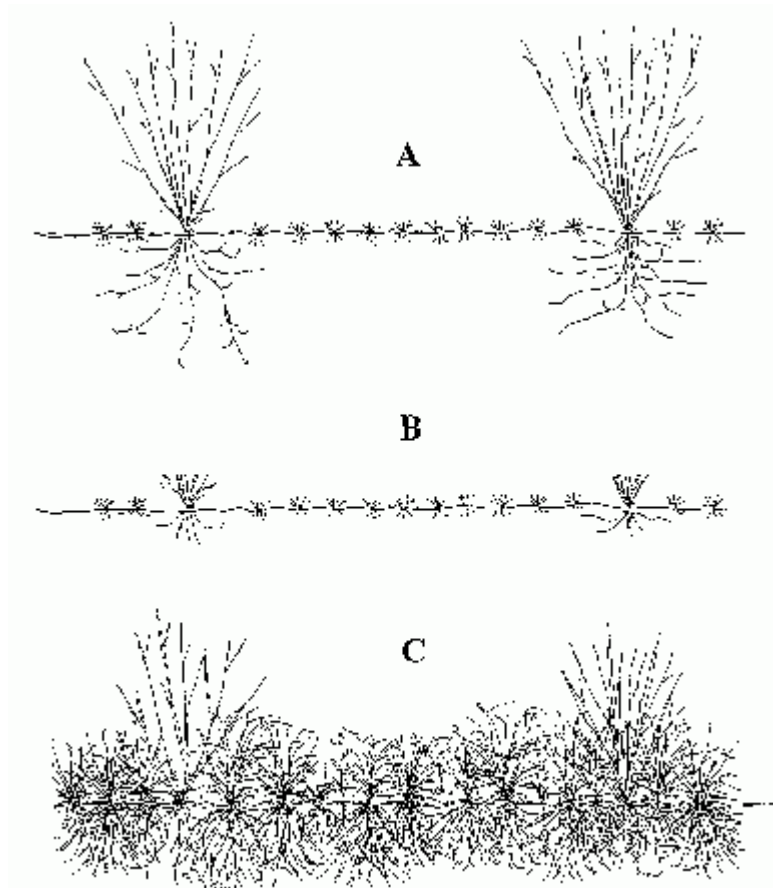


Fig. 5. Effect of grazing method on the competitive interactions between plants, particularly below ground. A: relatively unpalatable species gain an advantage for water and nutrients under continuous grazing. B: crash grazing, burning, herbicide or slashing reduce the biomass of all plants above and below ground. C: long rest periods and short, heavy graze periods enable desirable plants to form vigorous root systems and out-compete less desirable plants.

Considerable effort has been expended to find ways to "graze weeds into the ground" (Fig. 5B) using some form of crash grazing in otherwise set-stocked situations. Like ploughing, burning or spraying, short term results often appear promising, but in the longer term, the health of the grassland declines and the less desirable plants more often than not proliferate.

The use of high stock densities to apply grazing pressure to relatively unpalatable pasture components (Fig. 5B), can reduce ecosystem health to an even greater extent than selective grazing (Fig. 5A) if used repeatedly. In this scenario (Fig. 5B), the root biomass and root depth of all species will be reduced, as will litter cover, leading to greater fluctuations in soil temperature, reduced infiltration of rainfall, lower soil moisture levels, lower levels of soil

biological activity and reduced capacity for nutrient cycling. Plant community dynamics, particularly competitive interactions below ground, will be almost non-existent (Fig. 5B). The use of high stock density in this way differs from the strategic use of animal impact as defined by Savory (1988).

Given the same starting point as before (Fig. 5A), let us ignore the weeds, and instead concentrate on what we want. In order for the more desirable pasture components to produce vigorous top growth, and therefore vigorous roots, we need to allow sufficient plant growth between graze periods. Plant community dynamics will do the rest (Fig. 5C). Competition BELOW ground is the most effective way to reduce the vigor of established weeds.

To reduce the germination of new weed seedlings, groundcover needs to be maintained at 100% (plants plus plant litter), for 100% of the time. This again depends on appropriate grazing management. Well-mulched soils provide excellent establishment conditions for the perennial grasses regarded as desirable for livestock production. These plants evolved in soils high in organic matter whereas weedy species usually colonize bare ground.

Section 1.07 Conclusion

The way grasslands are managed affects not only their diversity and productivity, but also the extent to which they nourish soil organisms. The activities of these organisms are vitally important to both the cycling of nutrients and the maintenance of good soil structure, which in turn have positive feedback effects on plant growth and animal production.

When pastures are always short, natural nutrient cycles can't function. Degraded pastures can be supplemented with fertiliser, but this augmentation is unbalanced and usually only economical when commodity prices are high. In the current marketplace, the majority of livestock producers are faced with a negative cash flow situation and can little afford expensive off-the-shelf products. Furthermore, loss of groundcover as a result of unmanaged grazing leads to weed invasion and erosion, as well as off-site impacts such as sedimentation of dams and rivers.

Changes to conventional grazing practices which enhance ecosystem function have implications far beyond changes in botanical composition. Of particular importance from a rangeland health perspective, is the effect of appropriate grazing management on the infiltration of rainfall and the water-use efficiency of plants, drought survival, biodiversity, organic matter levels, soil biota, soil structure and the building of new topsoil.

Improvements in these factors can move us towards the restoration of hydrological balance on a catchment scale and most importantly, strengthen rural communities through their impact on farm profitability.

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Section 1.09 Author details

DLWC, PO Box 199a, Armidale, NSW, 2350, Australia. Ph: (02) 6772 5488 E-mail: cjones@dlwc.nsw.gov.au

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GROWING GRAPES IN PLACER & NEVADA COUNTIES

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Author: Cindy Fake, Horticulture & Small Farms Advisor, Nevada & Placer Counties

Placer and Nevada counties have a young, rapidly growing wine industry, composed of small vineyards and more than twenty small wineries. We are foothill counties and most of the grapes are grown at elevations between 1000 and 2500 feet. Most production is red, and we are able to produce some fine quality grapes because of our warm days and cool nights. We grow a wide range of varieties, including many lesser-known varieties that are in demand for blending. Contrary to many areas, the average prices paid for our grapes are actually increasing.

If you are interested in commercial production, i.e. selling your grapes, look at acreage and crush reports at [http://www.nass.usda.gov/Statistics by State/California/Publications/Grape Crush/indexgcb.asp](http://www.nass.usda.gov/Statistics%20by%20State/California/Publications/Grape%20Crush/indexgcb.asp). They provide information on varieties grown in the area and prices paid for each variety. Acreage reports are by county (Tables 9 & 10), and crush reports by district, we are in district 10.

Because of overplanting of grapes, if you want to sell your grapes, you should establish a relationship with a winery before you plant anything. Without a contract, selling grapes may be difficult. Cost of production studies are at <http://www.agecon.ucdavis.edu/outreach/crop/cost.htm>.

A major drawback in Placer/Nevada is the very limited agricultural labor pool. Growers who really need labor seem to find it, but the skill levels may vary. Many growers do vineyard maintenance themselves and look for contracts that include harvest and transport to the winery.

Grapes can grow on fairly infertile ground, and that may be preferable for quality. Foothill soils are frequently shallow and may have dense impermeable layers called hardpans, which require extensive land preparation. Most are either clay or decomposed granite and fairly acidic. At lower elevations, there are some neutral or slightly alkaline soils.

Soil testing

UC Cooperative Extension does not do soil testing. You do need to have your soil tested. Area labs include A & L Western Agricultural Labs, Inc. <http://www.al-labs-west.com/>, (209) 529-4080; Fruit Growers' Lab <http://www.fglinc.com/>, (530) 343-5818; Sunland Lab <http://sunland-analytical.com/>, (916) 852-8557. California labs will be able to provide the most accurate and appropriate information.

If you have different soil zones, you will need to take several samples and have them tested separately. You will need a basic panel of tests to find out pH and soil nutrient status. A pH of 6.5 is desirable. You also need to know CEC, ppm Ca, Mg, K, Na (base saturation %), pH, and Ca:Mg ratio. If you inform the lab that you want to grow winegrapes, they can give you appropriate fertilizer recommendations.

Your County Resource Conservation District and the Natural Resources Conservation



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11477 E Avenue (Bldg 306, DeWitt Center)
Auburn, California 95603
(530) 889-7385
FAX (530) 889-7397
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255 So Auburn (Veterans Memorial Bldg)
Grass Valley, California 95945
(530) 273-4563
FAX (530) 273-4769
E-Mail: cenevada@ucdavis.edu

Service can provide information about your soil type, texture, depth, and waterholding capacity, as well as assistance with irrigation and soil conservation practices. Both are listed in the phone book under US Department of Agriculture (USDA).

Find out how deep your soil is and whether or not you have a hard pan, which you can only do by digging deep (6-8 ft) holes and looking at what is there. Before putting in a vineyard, you need to do extensive land preparation, especially on heavy clay. Most grape experts consider neglecting initial soil preparation to be "penny wise and pound foolish". In other words, your vineyard and grape quality will suffer in the long run. You need to give your vines the best possible opportunity to establish a good root system to avoid future water and nutrient issues.

Once your soil is prepared, consider establishing cover crops in order to facilitate rainy season work in the vineyard. If you need to alter soil conditions such as pH, do it before planting. Add amendments before ripping or slip plowing so as to incorporate them.

Networking & Education

Get involved with one of the local grapegrower associations: Sierra Grape Growers Association <http://www.sierragrapegrowers.org/index.htm>
Placer County Wine & Grape Association <http://www.placerwineandgrape.org/>

They have speakers at their monthly meetings, which can be very helpful in getting started.

You also may be interested in the quarterly course taught at UC Davis on various aspects of vineyard management. More information and registration is available at <http://ucanr.org/ucdexvit>. Useful publications are at <http://anrcatalog.ucdavis.edu/GrapesGrapeProducts/>.

Varieties & rootstocks

The UC Integrated Viticulture website, <http://iv.ucdavis.edu/> provides extensive information on grape varieties and rootstocks. *Wine Grape Varieties in California*, UC ANR Publication 3419, has detailed rootstock and scion information. This book is available for sale at UCCE offices in Grass Valley and Auburn. There is also a list of resources in the vineyard establishment packet available at UCCE offices.

Red wine varieties - Barbera, Cabernet Franc, Cabernet Sauvignon, Carignane, Grenache, Merlot, Petite Sirah, Sangiovese, Syrah, Tempranillo, Zinfandel, among others.

White wine varieties - Sauvignon Blanc, Viognier, Semillon, Chardonnay, Chenin Blanc, French Colombard, Orange Muscat.

Commonly used rootstocks include 110R, 3309, 5C, 101-3C, Saint George, 140Ru, and 1103P. Rootstock choice depends on your soil depth, fertility and water situation. Some people use

cuttings ("own-rooted"), but this is not a recommended practice. There is good reason to use grafted vines. Rootstocks confer a number of properties such as vigor control, pest resistance, tolerance to water stress, etc. We do have *Phylloxera* insect pests in this area and they will kill an own-rooted vineyard. It is also recommended that you use certified planting material to be sure it is "clean", that is, free of known viruses and pests. Use the FPMS list of nurseries at <http://fpms.ucdavis.edu/Grape/CDFAGrapeProgram.html>

Pick several varieties you are interested in, contact a nursery and tell them where your land is, about your soil analysis, soil type and depth and ask for recommendations. Also talk to growers in your area.

Quarantines

There are internal quarantines in California for certain pests so your vines must be inspected by the County Ag Department before they are planted. Do not depend on the nursery to know about quarantines. You are responsible for legally importing your vines. Follow the guidelines as vines can be destroyed by the Ag Commissioner's staff if they do not meet quarantine criteria.

Good luck with your new vineyard!





INTERNET RESOURCES ON VITICULTURE



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COMPILED BY: Cindy Fake, Horticulture and Small Farms Advisor, Nevada & Placer Counties

Grape Production

UC Integrated Viticulture: Information on every aspect of growing table and wine grapes. <http://iv.ucdavis.edu/>

UC Davis Fruit and Nut Research and Information Center: Publications, organizations, information on grape production. <http://fruitsandnuts.ucdavis.edu/crops/grape.shtml>

UC Davis Cost of Production **Studies**: Information on the cost of establishing a vineyard and producing winegrapes. <http://coststudies.ucdavis.edu/files/grapewineim2005.pdf>

Sustainable Production Practices

<http://www.sustainablewinegrowing.org/> California Sustainable Winegrowing Alliance

<http://www.sarep.ucdavis.edu/ccrop/> Cover Crops Resource Page

<http://www.ams.usda.gov/nop/> National Organic Program Information

<http://tinyurl.com/usdasustviticulture> USDA Sustainable Viticulture

UC Publications and Classes

UC Division of Agriculture and Natural Resources Sustainable Agriculture Publications. Grape growing publications. <http://anrcatalog.ucdavis.edu/GrapesGrapeProducts/> UC ANR Publications are available in your county Cooperative Extension office.

UC Davis Extension Classes: Vineyard management and winemaking classes. <http://ucanr.org/ucdexvit>

Crush Reports: Information on varieties, tonnage, prices paid for winegrapes. We are in Crush District 10. <http://tinyurl.com/nass-usda-gov>

Registered Grape Nurseries <http://fpms.ucdavis.edu/Grape/CDFAGrapeProgram.html>

Soil Testing Laboratories

<http://www.fglinc.com/> Fruit Growers Labs

<http://www.al-labs-west.com/> A & L Western Ag Labs, Inc.

<http://sunland-analytical.com/> Sunland Lab

Sierra Grape Growers Association <http://www.sierragrapegrowers.org/index.htm>

Placer County Wine & Grape Association <http://www.placerwineandgrape.org/>

UC Integrated Pest Management Guidelines: Information on and pictures of pests and management recommendations. <http://www.ipm.ucdavis.edu/PMG/selectnewpest.grapes.html>



COOPERATIVE EXTENSION, UNIVERSITY OF CALIFORNIA

Placer County

WEB SITE: ceplacervevada.ucdavis.edu

Nevada County



11477 E Avenue (Bldg 306, DeWitt Center)
Auburn, California 95603

(530) 889-7385

FAX (530) 889-7397

E-Mail: ceplacer@ucdavis.edu

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United States Department of Agriculture, University of California, Placer and Nevada Counties cooperating.

255 So Auburn (Veterans Memorial Bldg)
Grass Valley, California 95945

(530) 273-4563

FAX (530) 273-4769

E-Mail: cenevada@ucdavis.edu



www.ipm.ucdavis.edu

Wine/Raisin Grape Year-Round IPM Program Annual Checklist

Supplement to UC IPM Pest Management Guidelines: Grape

These practices are recommended for a monitoring-based IPM program that reduces water quality problems related to pesticide use. Track your progress through the year using this form.

Each time a pesticide application is considered, review the Pesticide Application Checklist at the bottom of this form for information on how to minimize water quality problems. This program covers the major pests of grape. Details on carrying out each practice, information on additional pests, and additional copies of this form are available from the UC IPM Pest Management Guidelines: Grape at <http://www.ipm.ucdavis.edu/PMG>.

This program applies only to wine and raisin grapes; it does not include information for table grapes. For **table grapes**, see the Table Grape Year-Round IPM Program.

✓ Done	Delayed-dormant period activities
	What should you be doing at this time? On a warm day, monitor vines and spurs for: <ul style="list-style-type: none"> • Mealybugs • Ants associated with mealybugs and European fruit lecanium scale • Orange overwintering spider mites • Cutworm Keep records on a monitoring form. Treat** if needed according to the PMG.
	In coastal areas, check orange tortrix pheromone traps that were put up during the dormant period. <ul style="list-style-type: none"> • Keep records on a monitoring form.
	Just before budbreak, put up omnivorous leafroller pheromone traps. <ul style="list-style-type: none"> • Check traps twice weekly until a biofix date is established; thereafter, check traps weekly. • Keep records on a monitoring form.
	If sharpshooters are a problem in your area, set out sticky traps just before budbreak for: <ul style="list-style-type: none"> • Glassy-winged sharpshooter In coastal regions near riparian and landscape areas: <ul style="list-style-type: none"> • Blue-green sharpshooter Change traps weekly. Keep records on a monitoring form.
	Keep records of other pests or pest damage you may see. <ul style="list-style-type: none"> • Rodents • Branch and twig borer • Click beetles • Bud beetles • <i>Eutypa</i>

✓ Done	Budbreak period activities What should you be doing at this time?
	On a warm day, monitor vines and spurs for: <ul style="list-style-type: none"> • Mealybugs • Ants associated with mealybugs and European fruit lecanium scale • Orange overwintering spider mites • Cutworm • Thrips Keep records on a monitoring form. Treat** if needed according to the PMG.
	Check pheromone traps for: <ul style="list-style-type: none"> • Omnivorous leafroller • Orange tortrix in coastal areas Keep records on a monitoring form.
	Monitor leaf wetness. Track powdery mildew ascospore release and mildew risk index. <ul style="list-style-type: none"> • Treat** if needed according to the PMG.
	Consider treating** for phomopsis cane and leaf spot if rain continues after budbreak.
	Remove vines that have spring symptoms of Pierce's disease.
	Check sticky traps for sharpshooters: <ul style="list-style-type: none"> • Glassy-winged sharpshooter In coastal regions near riparian and landscape areas: <ul style="list-style-type: none"> • Blue-green sharpshooter Change traps weekly. Keep records on a monitoring form.



Wine and Raisin Grape Year-Round IPM Program

✓ Done	Rapid shoot growth period activities
	What should you be doing at this time?
	Look for thrips if cold weather persists.
	Look for spider mites and their natural enemies weekly on first-emerging leaves. <ul style="list-style-type: none"> • Map areas of concern for bloom monitoring.
	Monitor leafhoppers weekly starting a month after budbreak or whenever first nymphs appear. <ul style="list-style-type: none"> • Keep records on a monitoring form.
	Continue checking pheromone traps for: <ul style="list-style-type: none"> • Omnivorous leafroller • Orange tortrix in coastal areas Keep records on a monitoring form.
	In southern San Joaquin Valley, put up vine mealybug pheromone traps around April 1 and check every two weeks. <ul style="list-style-type: none"> • If males are caught or honeydew, sooty mold, or ants are found, look for female infestations on surrounding vines. • Keep records on a monitoring form. • Treat** if needed according to PMG.
	Monitor caterpillars if they have been a problem in the past: <ul style="list-style-type: none"> • Western grapeleaf skeletonizer • Grape leafroller • Orange tortrix in coastal vineyards • Omnivorous leafroller Map areas of concern for bloom monitoring.
	If European fruit lecanium scale has been a problem in the past, monitor female development on old wood.
	Manage ants if mealybugs and scale are a problem.
	Monitor sharpshooters: <ul style="list-style-type: none"> • Glassy-winged sharpshooter In coastal regions near riparian and landscape areas check for: <ul style="list-style-type: none"> • Blue-green sharpshooter Change sticky traps weekly. Keep records on a monitoring form.
	Monitor for flagging. If you see a flag, distinguish between <i>Botrytis</i> shoot blight and branch and twig borer.
	Monitor leaf wetness. Track powdery mildew ascospore release and mildew risk index. <ul style="list-style-type: none"> • Treat** if needed according to PMG.
	Survey weeds to plan a weed management strategy. <ul style="list-style-type: none"> • If herbicides** are used, use the late-spring weed survey form to record your observations and make pre- and postemergent herbicide selection decisions.
	Keep records of other pests or pest damage you may see: <ul style="list-style-type: none"> • Eutypa dieback • Phomopsis



Wine and Raisin Grape Year-Round IPM Program

✓ Done	Bloom to veraison period activities
	<p>What should you be doing at this time?</p> <p>Monitor leafhopper and spider mites weekly.</p> <ul style="list-style-type: none"> • Keep records on a monitoring form. • Treat** if needed according to PMGs.
	<p>Monitor for <i>Botrytis</i> and powdery mildew by inspecting leaves and shoots.</p>
	<p>If European fruit lecanium scale has been a problem in the past, monitor for egg hatch to time treatment**.</p>
	<p>Check pheromone traps for:</p> <ul style="list-style-type: none"> • Omnivorous leafroller • Orange tortrix (in central coast areas) <p>Keep records on a monitoring form.</p>
	<p>In areas other than southern San Joaquin Valley, put up vine mealybug pheromone traps. In all areas, check traps every two weeks.</p> <ul style="list-style-type: none"> • If males are caught or honeydew, sooty mold, or ants are found, look for female infestations on surrounding vines. • Keep records on a monitoring form. • Treat** if needed according to PMG.
	<p>Monitor <i>Pseudococcus</i> mealybugs by looking for honeydew, sooty mold, and ant activity.</p> <ul style="list-style-type: none"> • Keep records on a monitoring form. • If you see crawlers, treat** if needed according to PMG.
	<p>To reduce possible summer rot, <i>Botrytis</i>, and leafhoppers, remove basal leaves or basal lateral shoots beginning around berry set.</p> <ul style="list-style-type: none"> • Time leaf pull before first-generation grape leafhoppers become adults. <p>Treat** for <i>Botrytis</i> prior to rain, if leaves are not removed.</p>
	<p>Monitor caterpillars if they have been a problem in the past:</p> <ul style="list-style-type: none"> • Omnivorous leafroller • Orange tortrix • Grape leafroller • Western grapeleaf skeletonizer <p>Keep records on a monitoring form.</p>
	<p>Monitor sharpshooters:</p> <ul style="list-style-type: none"> • Glassy-winged sharpshooter <p>In coastal regions near riparian and landscape areas check for:</p> <ul style="list-style-type: none"> • Blue-green sharpshooter <p>Change sticky traps weekly. Keep records on a monitoring form.</p>
	<p>Keep a record of other pests or pest damage you may see;</p> <ul style="list-style-type: none"> • Grasshopper • Whitefly



Wine and Raisin Grape Year-Round IPM Program

✓ Done	Veraison period activities What should you be doing at this time?
	Monitor leafhoppers and spider mites weekly. <ul style="list-style-type: none"> • Keep records on a monitoring form. Treat** if needed according to PMGs.
	Check pheromone traps for: <ul style="list-style-type: none"> • Omnivorous leafroller • Orange tortrix in coastal areas Keep records on a monitoring form.
	Check vine mealybug pheromone traps. <ul style="list-style-type: none"> • If males are found, or if honeydew, sooty mold, or ant activity is found, look for female infestations on surrounding vines. • Educate field crew to flag cluster infestations for treatment. Treat** if needed according to PMG.
	Monitor grape and obscure mealybugs. <ul style="list-style-type: none"> • Keep records on a monitoring form. • If you see crawlers, treat** if needed according to PMG.
	Monitor sharpshooters: <ul style="list-style-type: none"> • Glassy-winged sharpshooter Check traps weekly. Keep records on a monitoring form.
	Look for vine symptoms of Pierce's disease.
	If rain occurs shortly after veraison, monitor for <i>Botrytis</i> .
	Monitor caterpillars if they have been a problem in the past: <ul style="list-style-type: none"> • Omnivorous leafroller • Orange tortrix • Grape leafroller • Western grapeleaf skeletonizer Keep records on a monitoring form.
	Look on roots of weakened vines for galls or phylloxera.
	If necessary manage birds with netting or scare devices as fruit ripens.
	Keep a record of other pests or pest damage you may see. <ul style="list-style-type: none"> • Whitefly • European fruit lecanium • Grasshoppers



✓ Done	Harvest period activities What should you be doing at this time?
	Be aware that high populations of adult leafhoppers may interfere with hand harvesting.
	Monitor for grape, obscure, and vine mealybugs. <ul style="list-style-type: none"> • Look for cluster infestations and mark on map. • Educate harvest crew to flag cluster infestations of vine mealybug for treatment. • Treat** vine mealybug if needed according to PMG.
	If you have vine mealybug, steam sanitize equipment before moving to an uninfested area of the vineyard.
	For Pierce's disease: <ul style="list-style-type: none"> • Flag vines with symptoms for removal.
	If necessary, continue managing birds with netting or scare devices.
	Treat** for <i>Botrytis</i> prior to any anticipated rain.
	Sample soil and roots for nematodes; look at roots for galls and phylloxera.
	Monitor glassy-winged sharpshooter: <ul style="list-style-type: none"> • Check traps weekly and keep records on a monitoring form.

✓ Done	Postharvest period activities What should you be doing at this time?
	If necessary, treat** for vine mealybug immediately after harvest according to the PMG.
	To reduce risk of transferring vine mealybug, do not place winery pomace in the vineyard; compost pomace or cover piles securely with clear plastic.
	Look for symptoms of Pierce's disease on vines and flag for removal.
	Look for European fruit lecanium on leaves.
	If you desire a cover crop, seed after harvest.



Wine and Raisin Grape Year-Round IPM Program

✓ Done	Dormant period activities What should you be doing at this time?
	Apply lime sulfur** for powdery mildew in areas other than Madera, Fresno, and Tulare counties.
	In coastal areas, set out orange tortrix pheromone traps by December. <ul style="list-style-type: none"> • Check traps twice weekly until a biofix date is established; thereafter, check traps weekly. • Keep records on a monitoring form.
	If present, treat** for Phomopsis cane and leaf spot before rainfall.
	Sample for nematodes in January or February.
	Carry out dormant-season sanitation activities: <ul style="list-style-type: none"> • Prune late in dormancy after rains to reduce wound infections. • Destroy prunings of older infested wood to reduce pest sources. • Remove dried grape clusters on vines and disc weeds and clusters where orange tortrix or omnivorous leafroller is a problem. • In vineyards with a history of branch and twig borers, examine old pruning scars and dead parts of vines for brown frass and wood dust. • If you have vine mealybug, steam sanitize equipment before moving to uninfested area of the vineyard.
	Survey weeds to plan a weed management strategy. <ul style="list-style-type: none"> • If herbicides** are used, use the late-winter survey form to record your observations and make pre- and postemergent herbicide selection decisions.



✓ Done	**Pesticide application checklist
	<p>When planning for possible pesticide applications in an IPM program, review and complete this checklist to consider practices that minimize environmental and efficacy problems.</p> <ul style="list-style-type: none"> ✓ Choose a pesticide from the UC IPM Pest Management Guidelines for the target pest considering: <ul style="list-style-type: none"> ▪ Impact on natural enemies. ▪ Potential for water quality problems using the UC IPM WaterTox database. (For more information, see http://www.ipm.ucdavis.edu/TOX/simplewatertox.html.) ▪ Impact on aquatic invertebrates. (For more information, see <i>Pesticide Choice</i>, UC ANR Publication 8161, http://anrcatalog.ucdavis.edu/pdf/8161.pdf.) ▪ Chemical mode of action if pesticide resistance is an issue. ✓ Select an alternative chemical or nonchemical treatment when risk is high. <ul style="list-style-type: none"> ▪ Choose sprayers and application procedures that keep pesticides on target. ▪ Identify and take special care to protect sensitive areas (for example, waterways or riparian areas) surrounding your application site. ▪ Review and follow label for pesticide handling, storage, and disposal guidelines. ▪ Check and follow restricted entry intervals (REI) and preharvest intervals (PHI). ▪ After an application is made, record application date, product used, rate, and location of application. Follow up to confirm that treatment was effective. ✓ Consider water management practices that reduce pesticide movement off-site. (For more information, see UC ANR Publication 8214, <i>Reducing Runoff from Irrigated Lands: Causes and Management of Runoff from Surface Irrigation in Orchards</i>, http://anrcatalog.ucdavis.edu/pdf/8214.pdf.) <ul style="list-style-type: none"> ▪ Install an irrigation recirculation or storage and reuse system. ▪ Use drip rather than sprinkler or flood irrigation. ▪ Limit irrigation to amount required using soil moisture monitoring and evapotranspiration (ET). ▪ Consider vegetative filter strips or ditches. (For more information, see <i>Vegetative Filter Strips</i>, UC ANR Publication 8195, http://anrcatalog.ucdavis.edu/pdf/8195.pdf.) ▪ Redesign inlets into tailwater ditches to reduce erosion. ✓ Consider management practices that reduce air quality problems. <ul style="list-style-type: none"> ▪ When possible, choose pesticides that are not in emulsifiable concentrate (EC) form which release volatile organic compounds (VOCs). VOCs react with sunlight to form ozone, a major air pollutant.



VEGETABLE PLANT FAMILIES AND THEIR CHARACTERISTICS

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AUTHOR: **Cindy Fake**, Horticulture and Small Farm Advisor, Placer & Nevada Counties

SOLANACEAE: NIGHTSHADE/ TOBACCO FAMILY

Tomato, eggplant, bell pepper, chili pepper, tobacco, and potato.

Description

Alternate leaves; simple, lobed, or biternate; often pubescent; characteristic odor. Flower with connivent anthers (come to a point); 5 petals; fruit is a berry. Many perennial, grown as annuals.



Cultural Characteristics

Many common diseases and pests: tobacco mosaic, verticillium/fusarium fungi and nematodes. Prefers rich, damp soil, lots of organic matter.

FABACEAE OR LEGUMINOSAE PEA/BEAN FAMILY

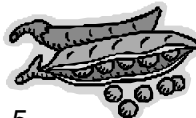
Peas, green/string beans, hyacinth bean, cowpea, peanut.

Huge family of enormous economic importance. *Rhizobium* spp. bacteria form nodules on roots to fix N. Subfamilies according to flower type.

Papilionoideae: Bilaterally symmetric flowers. Pea flower: banner, wings and keel. Most fix N. Vegetables & cover crops.

Mimosoideae: Numerous stamens. *Acacia*, *albizzia* spp., many N fixing.

Caesalpinoideae:
10 or less
stamens, slightly
radially asymmetric, 5
petals, few fix N.



Description

Alternate, compound leaves, either pinnate or trifoliate. Fruit a legume: splits open, seeds along one side.

Cultural Characteristics

High protein leaves and seeds. Avoid adding too much N, use small amounts of well rotted compost. Some long day flowering beans. Transplanting reduces N fixing ability.

CUCURBITACEAE: GOURD FAMILY

Cucumbers, melons, watermelon, winter squash, zucchini, gourds, luffa.

Description

Usually annual; climbing or prostrate; often bristly haired; with tendrils; large, alternate, simple, palmately lobed leaves. Flowers usually unisexual, plants usually monoecious.

Cultural Characteristics

Very fast growing, need to be kept moist, not wet, use lots of compost. Does not transplant well unless less than three weeks old. Grow on trellis. Subject to mildews and blights. Cucumber

& flea beetles cause problems.

MALVACEAE: HIBISCUS/ MALLOW FAMILY

Okra, roselle, cotton, hibiscus.

Description

Palmately lobed or veined leaves. Often hairy; dehiscent capsule fruits; many carpels; large flowers with staminate spray in center. Stamens united by filaments in tube around pistil.

Cultural Characteristics

Need sun and heat, drought tolerant. Does not transplant well. Very susceptible to flea beetles, but grows anyway. Sometimes aphids.



ALLIACEAE: ONION FAMILY (Liliaceae or Amaryllidaceae)

Onion, garlic, leek, and chive.

Description

Monocots, push up leaves from base, long thin leaves, flowers in racemes, store nourishment in swollen bulbs (underground shoots), long life cycle, mostly biennial or perennial.

Cultural Characteristics

Cool weather for leaves, hot dry weather for bulbs. Very shallow roots. Bolt, if flower stems are not removed. Like loamy



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Placer County

WEB SITE: ceplacervevada.ucdavis.edu

Nevada County



11477 E Avenue (Bldg 306, DeWitt Center)
Auburn, California 95603

(530) 889-7385
FAX (530) 889-7397

E-Mail: ceplacer@ucdavis.edu

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255 So Auburn (Veterans Memorial Bldg)
Grass Valley, California 95945

(530) 273-4563
FAX (530) 273-4769

E-Mail: cenevada@ucdavis.edu

soils, not clayey, nor too sandy. Need weeding, adequate water.

POACEAE/GRAMINAE:GRASSES/ GRAINS

Corn, rice, wheat, lemon grass, sugar cane.

Description

Monocots, strap-shaped leaves with sheaths. Fibrous roots, rhizomes or stolons. Huge family, most important economic crops. Alternate, simple leaves. Tiny, wind-pollinated, often unisexual flowers.

Cultural Characteristics

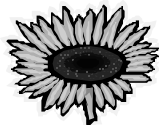
Heavy feeders, need lots of N: organic matter or fertilizer. Plants add organic matter to soil via fibrous roots. Plant in blocks to ensure pollination. Some perennial, mostly annuals.

ASTERACEAE/COMPOSITAE: SUNFLOWER/ASTER FAMILY

Lettuce, artichoke, calendula, zinnia, marigold, sunflower.

Description

Composite flowers: flower head made up of many tiny ray and disk flowers. Alternate simple or compound leaves, often with wide central vein. Watery or milky sap. Attracts pollinators.



Cultural Characteristics

Fast growing, shallow roots, grow lettuces in cool season or shade with larger plants. Does not do well in heavy clay. Add plenty of organic matter. Few pests, attract beneficial insects.

BRASSICACEAE/ CRUCIFERAE:MUSTARD FAMILY

Broccoli, cabbage, cauliflower, kale, mustard, Pak choi, radish.



Description

Alternate, simple leaves with waxy cuticle or hairs. Crucifer: 4 petalled flower, 4 + 2 stamens, mostly biennial. Plants have characteristic sulfur odor.

Cultural Characteristics

Usually cool season crop. Can make do with very little water because of waxy cuticle. Shallow rooted. Does not do well in acid soil; add plenty of organic matter. Cabbage moth larvae eat leaves & hearts, so tie it up. Club root can be a problem if not rotated.

CHENOPODIACEAE: GOOSEFOOT FAMILY

Beet, chard, spinach.

Description

Annual or biennial (beet). Alternate, large, simple leaves with continuous leaf surface. Tiny green flowers, easily confused with amaranths. Seed in tiny fruits. Several seeds/fruit (what you plant are fruits).

Cultural Characteristics

Very deep rooted (up to 3 meters). Breaks up soil, recycles nutrients, good to precede carrots. Cool season vegetables. Need well-drained soil, well rotted compost. Do not do well in acid soil. Need to be watered deeply. Leafminer pests.

AMARANTHACEAE: AMARANTH/ PIGWEED FAMILY

Amaranths, celosias.

Description

Simple, alternate or opposite leaves; often pubescent flowers, usually in spikes or racemes. Weeds and vegetables.

Cultural Characteristics

Very hardy, drought tolerant, lots of sun, long harvest period, likes manure. Pinch off flowers to maintain leaf production.

APIACEAE/UMBELLIFERAE: PARSLEY FAMILY

Carrot, parsley, coriander, fennel, celery.

Description

Usually cooler season crop. Needs water. Sandy or loamy, well drained soil. (not heavy clay). No fresh manure, add rock phosphate/ashes. Pests: carrot fly and larvae. Very slow germinating seed. Easily cross-pollinate.



LAMIACEAE/LABIATAE: MINT FAMILY

Mints, basil, rosemary, thyme, oregano, sage.

Description

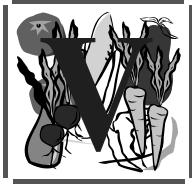
Aromatic herbs, many perennial, sometimes shrubs, four-sided stems, opposite or whorled leaves, bilabiate flowers.

Cultural Characteristics

Drought tolerant, tolerate poor soils. Extensive, invasive roots, perennials spread easily. Large, thick, canopy.

References

Knott's Handbook for Vegetable Growers. 1997. D.N. Maynard and G.J. Hochmuth.
Tropical Crops: Dicotyledons. 1987. J.W. Pursglove.
Vascular Plant Families. 1977. J.P. Smith.



Vegetable Characteristics

Optimum Temperatures for Different Vegetables:

	Optimum T°	Minimum	Maximum	Vegetable
Cool Season	55-75°	45°	85°	Chicory, chive, garlic, leek, onion, shallot
	60-65°	40°	75°	Beet, broccoli, Brussels sprouts, cabbage, chard, collards, horseradish, kale, radish, spinach, turnip
	60-65°	45°	75°	Artichoke, carrot, cauliflower, celery, Chinese cabbage, endive, lettuce, mustard, parsley, peas, potato
Warm Season	60-70°	50°	80°	Lima bean, snap bean
	60-75°	50°	95°	Sweet corn, black-eyed pea, New Zealand spinach
	65-75°	50°	90°	Chayote, pumpkin, squash
	65-75°	60°	90°	Cucumber, cantaloupe
	70-75°	65°	80°	Sweet pepper, tomato
	70-85°	65°	95°	Eggplant, chili pepper, okra, Roselle, sweet potato, watermelon

Rooting Depths for Different Vegetables:

Shallow (18-24")	Moderately deep (36-48")	Deep (> 48")
broccoli	bush & pole beans	artichoke
Brussels sprouts	beet	asparagus
cabbage	cantaloupe	Lima bean
cauliflower	carrot	parsnip
celery	chard	pumpkin
Chinese cabbage	cucumber	sweet potato
corn	eggplant	tomato
endive	mustard	watermelon
garlic	peas	winter squash
leek	peppers	
lettuce	summer squash	
onion	turnip	
parsley		
potato		
radish		
spinach		
strawberry		

Table 2
Vegetable Gardening at a Glance: How to Plant and Store

Recommended Planting Dates for Sections of California*				General Planting Requirements				Storage Conditions			
Vegetables	North and North Coast: Monterey County north	South Coast: San Luis Obispo County south	Interior Valleys: Sacramento, San Joaquin, and similar valleys	Desert Valleys: Imperial, Coachella valleys	Crop Type	Amount To Plant (Family of Four)	Distance in inches Between Plants In Rows**	Distance in inches Between Rows - No Beds**	Best Temp (°F)	Time Length (Weeks)	How to Preserve***
Artichoke ³	Aug.-Dec.	May - July	July	Sept.	C	3 - 4 plants	48	60	32	1 - 2	Freeze whole, can, dry, or freeze hearts
Asparagus ³	Jan. - March	Jan. - Feb.	Jan. - Feb.	Feb. - Apr.	C	30 - 40 plants	12	60	32	3 - 4	Can, dry, or freeze
Beans, lima ¹	May - June	May - June	May - June	---	W	15 - 25 ft. row	6 bush 24 pole	30	40	1 - 3	Can, dry, or freeze
Beans, snap ^{1,2}	July May - June	March - Aug.	Apr. - May July - Aug.	Jan. - March Aug.	W	15 - 25 ft. row	3 bush 24 pole	30 ⁴	45-55	1 - 2	Can, dry, or freeze
Beets ^{1,2}	Feb. - Aug.	Jan. - Sept.	Feb. - Apr. Aug.	Sept - Jan.	C	10 - 15 ft. row	2	18 ⁴	32	3 - 10	Can, dry, or freeze
Broccoli ^{2,3}	Feb. - Apr. Aug. - Sept.	June - July Jan. - Feb.	Dec. - Feb. July	Sept.	C	15 - 20 ft. row	9 - 12	36	32	1 - 2	Dry or freeze
Brussels sprouts ³	Feb - May	June - July	---	---	C	15 - 20 ft. row	24	36	32	3 - 4	Dry or freeze
Cabbage ^{1,3}	Jan. - Apr. July - Sept.	Aug. - Feb.	July Feb.	Sept. - Nov.	C	10 - 15 plants	24	36	32	12 - 16	Dry or freeze
Cabbage ¹ , Chinese	July - Sept.	Aug. - Oct.	Aug.	Aug. - Nov.	C	10 - 15 ft. row	6	30 ⁴	32	2 - 3	Dry or freeze
Cantaloupes/ Other melons	May	Apr. - May	Apr. - June	Jan. - Apr. July	W	5 - 10 hills	12	72	40-50	2 - 4	Freeze
Carrots ^{1,2}	Jan. - May July - Aug	Jan. - Sept.	Aug. - Sept Feb. - Apr.	Sept - Dec.	C	20 - 30 ft row	2	24 ⁴	32	16 - 20	Can, dry or freeze
Cauliflower ³	June - July Jan.- Feb.	July - Oct. Feb.	July - Aug.	Aug. - Sept.	C	10 - 15 plants	24	36	32	2 - 3	Pickle, dry, or freeze
Celeriac	March - June	March - Aug.	June - Aug.	---	C	10 - 15 ft row	4	24 ⁴	32	8 - 16	Can, dry or freeze

Table 2 (continued)
Vegetable Gardening at a Glance: How to Plant and Store

Recommended Planting Dates for Sections of California*				General Planting Requirements					Storage Conditions		
Vegetables	North and North Coast: Monterey County north	South Coast: San Luis Obispo County south	Interior Valleys: Sacramento, San Joaquin, and similar valleys	Desert Valleys: Imperial, Coachella valleys	Crop Type	Amount To Plant (Family of Four)	Between Plants In Rows (distance in inches**)	Between Rows - No Beds (distance in inches**)	Best Temp (°F)	Time Length (Weeks)	How to Preserve***
Celery ^{1,3}	March - June	Apr. - Aug.	June- Aug.	---	C	20 - 30 ft row	5	24 ⁴	32	8 - 16	Can, dry or freeze
Chard ¹	Feb. - May Aug.	Feb. - May	Feb. - Aug.	Sept. - Oct	C	3 - 4 plants	12	30	32	1 - 2	Freeze
Chayote	---	Apr. - May	May - June	---	W	1 - 2 plants	72	Use trellis	---	---	Use fresh
Chives ¹	Apr.	Feb. - Apr.	Feb. - March	Sept. - Feb.	C	1 clump	---	---	---	---	Use fresh
Corn, sweet ²	May - July	March - July	March - July	Feb. - March	W	20 - 30 ft	12	36	32	1/2 - 1	Can, dry or freeze
Cucumbers	Apr. - June	Apr. - June	Apr. - July	Feb. - May	W	6 plants	24	48	45-55	1 - 2	Freeze, pickle or puree
Eggplant ^{1,3}	May	Apr. - May	Apr. - May	Feb. - Apr.	W	4 - 6 plants	18	36	50-60	1 - 2	Dry or freeze
Endive ¹	March - July	Dec. - Aug.	Jan., Apr.	Sept. - Dec.	C	10 - 15 ft row	10	24 ⁴	32	2 - 3	Use fresh
Florence Fennel	March - July	Feb. - July	Aug.	Sept. - Nov.	C	10 - 15 ft row	4	30 ⁴	32	2 - 3	Can, dry or freeze
Garlic ¹	Oct. - Dec.	Oct. - Dec	Oct. - Dec.	Sept. - Nov.	C	10 - 20 ft row	3	18 ⁴	65-70	24 - 32	Use fresh
Kohlrabi ¹	July - Aug.	Jan. Aug. - Sept.	Aug.	Oct. - Nov.	C	10 - 15 ft row	3	24	32	2-4	Use fresh
Leeks	Feb. - Apr.	Jan. - Apr.	Jan. - Apr.	---	C	10 ft row	2	24	32	4 -12	Use fresh
Lettuce ^{1,2}	Feb. - Aug.	Aug. - Apr.	Aug. Nov. - March	Sept. - Dec.	C	10 - 15 ft row	12 head 6 leaf	24	32	2 - 3	Use fresh
Mustard	Apr. July - Aug.	Aug. - Feb.	Aug. - Apr.	Oct. - Dec.	C	10 ft row	8	24 ⁴	32	1 - 2	Use fresh
Okra	May	Apr. - May	May	March	W	10 - 20 ft row	18	36	32	50 - 60	Use fresh

Table 2 (continued)
Vegetable Gardening at a Glance: How to Plant and Store

Vegetables	Recommended Planting Dates for Sections of California*				General Planting Requirements				Storage Conditions		
	North and North Coast: Monterey County north	South Coast: San Luis Obispo County south	Interior Valleys: Sacramento, San Joaquin, and similar valleys	Desert Valleys: Imperial, Coachella valleys	Crop Type	Amount To Plant (Family of Four)	Between Plants In Rows (distance in inches**)	Between Rows - No Beds (distance in inches**)	Best Temp (°F)	Time Length (Weeks)	How to Preserve***
Onions ¹ (bulb)	Jan. - March	Feb. - March	Nov. - March	Oct. - Nov.	C	30 - 40 ft. row	3	18 ⁴	32 - 36	12 - 32	Can, dry or freeze
Onions ^{1,2,3} (green)	Apr. - July	All year	Aug. - Dec.	Sept. - Jan.	C	---	---	---	85-90	---	Use fresh
Parsley ¹	Dec. - May	Dec. - May	Dec. - May	Sept. - Oct.	C	1 - 2 plants	8	24	32	1 - 2	Dry or freeze
Parsnips	May - June	March - July	May - July	Sept. - Oct.	C	10 - 15 ft row	3	24 ⁴	32	8 - 16	Freeze
Peas ^{1,2}	Jan. - Apr. Sept. - Oct.	Aug. Dec. - March	Sept. - Jan.	Sept. - Oct. Jan. - Feb.	C	30 - 40 ft row	2	36 bush	32	1 - 2	Can, dry or freeze
Peppers ^{1,3}	May	Apr. - May	May	March	W	5 - 10 plants	24	36	45-55	4 - 6	Can, dry or freeze
Potatoes ³ , sweet	May	Apr. - May	Apr. - June	Feb.-June	W	50 - 100 ft row	12	36	55-60	8 - 24	Can, dry or freeze
Potatoes, white	Early: Feb. Late: Apr. - May	Feb. - May June - Aug.	Feb. - March Aug.	Dec. - Feb.	C	50 - 100 ft row	12	30	40-45	12 - 20	Can, dry or freeze
Pumpkins	May	May - June	Apr. - June	March - July	W	1 - 3 plants	48	72	55	8 - 24	Can, dry or freeze
Radish ^{1,2}	All year	All year	Sept. - Apr.	Oct. - March	C	4 ft row	1	6 ⁴	32	---	Use fresh
Rhubarb ³	Dec. - March	Dec. - Jan.	Dec. - Feb.	---	C	2 - 3 plants	36	48	32	2 - 3	Can or freeze
Rutabaga	July March - Apr.	July - Sept. Aug - March	Aug.	Oct. - Dec.	C	10 - 15 ft row	3	6 ⁴	32	8 - 16	Freeze
Spinach ¹	Aug. - Feb.	Aug. - March	Sept. - Jan.	Sept. - Nov.	C	10 - 20 ft row	3	18 ⁴	32	1 - 2	Dry or freeze
Squash ¹ , summer	May - July	Apr. - June	Apr. - July	Feb. - March	W	2 - 4 plants	24	48	50-55	2 - 3	Can, dry or freeze

Table 2 (continued)
Vegetable Gardening at a Glance: How to Plant and Store

Recommended Planting Dates for Sections of California*				General Planting Requirements				Storage Conditions			
Vegetables	North and North Coast: Monterey County north	South Coast: San Luis Obispo County south	Interior Valleys: Sacramento, San Joaquin, and similar valleys	Desert Valleys: Imperial, Coachella valleys	Crop Type	Amount To Plant (Family of Four)	Between Plants In Rows (distance in inches**)	Between Rows - No Beds (distance in inches**)	Best Temp (°F)	Time Length (Weeks)	How to Preserve***
Squash ¹ winter	May	Apr. - June	Apr. - June	Feb. - March Aug.	W	2 - 4 plants	24 - 48	72	55	8 - 24	Can, dry or freeze
Tomatoes ^{1,3}	May	Apr. - July 15	Apr. - May	Dec. - March	W	10 - 20 plants	18 - 36	36 - 60	55-65	1 - 2	Can, dry or freeze
Turnips ¹	Jan., Aug.	Jan. Aug. - Oct.	Feb., Aug.	Oct. - Feb.	C	10 - 15 ft row	2	18 ⁴	32	8 - 12	Can
Watermelons	May - June	Apr. - June	Apr. - June	Jan. - March	W	6 plants	60	72	40	2 - 3	Freeze

¹This crop is suitable for a small garden if compact varieties are grown.

² In a suitable climate, these crops can be planted more than once/year for a continuous harvest.

³ Transplants, shoots, or roots are used for field planting.

⁴ If grown in beds, plant two rows per bed. Space the beds about 32 - 40 inches apart and make the tops of the beds 18 inches wide.

*Since the areas shown here are large, planting dates are only approximate, as the climate may vary even in small sections of the state. Contact experienced gardeners in your community and experiment on your own to find more precise dates.

**Planting distances listed here are standards. Many crops can be spaced more closely for intense production.

***From Vegetable Gardening Illustrated, Sunset Publishing Corp., Menlo Park, CA (June 1994)

Vegetable Eco-Requirements and Cultural Practices

<i>Spring/ Summer Crop</i>	<i>Time to harvest</i>	<i>Nutrient needs:</i>		<i>Light needs</i>	<i>Trellis or staking options</i>	<i>Pruning/ suckering/ thinning</i>	<i>Other</i>	<i>Irrigation:</i>	
		<i>Planting</i>	<i>Fruit set or mid-season</i>					<i>Water needs</i>	<i>Comments</i>
<i>Green Onion</i>	60 d. after germ., seed every 2 wks thru July	lots of compost		full sun to part shade, understory crop		thinning may be needed, 2-3" btw. plants	weeding		
<i>Peas (early spring-summer)</i>	65-75 days after seeding	soak seeds overnight before seeding; avoid too much N		full sun	string, or 2-3 plants/pole		pick frequently	moderate, keep moist	no overhead watering
<i>Bell & Chili Pepper</i>	65-80 days after transplant	add N at planting to assure good leaf coverage	side dress w/compost	full sun, part shade or shade cloth in hot location	may need stake	remove first flowers if canopy is small	pick frequently	water soil, not plant	
<i>Greens: arugula, NZ spinach</i>	35-45 days after seeding	need N		part shade in warm location		do not allow to go to seed	harvest outside leaves		drip, wick
<i>Summer squash, zucchini</i>	50-60 days	add compost/manure after germination	side dress w/compost	full sun		1 plant/container	pick frequently, when 6-8" long	needs moist, not wet soil	
<i>Tomato</i>	harvest 70-90 days after transplant	lots of compost	side dress w/compost	full sun, but high T° will lower fruit set	Indeterminate vars. cages, stakes or basket weave			keep soil moist but not saturated	allow to dry out betw. waterings after fruit set

Vegetable Eco-Requirements and Cultural Practices

Spring/ Summer Crop	Time to harvest	Nutrient needs:		Light needs	Trellis or staking options	Pruning/ suckering/ thinning	Other	Irrigation:	
		Planting	Fruit set or mid-season					Water needs	Comments
Green/ Snap Bean	45-70 days, seed at 2 week intervals	avoid too much N. humus	P & K at bloom/fruit set	full sun	string, or 2-3 plants/pole	2-3 " between plants	pick frequently	keep soil moist but not saturated!	
Beet	55-75 days after germination	add lime or wood ash to acid soil, also needs P		full sun to part shade, under- story crop in hot location		thin at 2-3 leaf stage, 2-3 " between plants	weeding	moderate, keep moist	
Chinese Cabbage	80-90 days (70 for baby)	needs fertile soil, esp. N		full sun to part shade		harvest leaves or pick young			
Cantaloupe	90 days	add compost/ manure after germination	side dress w/compost	full sun	trellis vines, indiv. support for ea. fruit			high, needs good drainage	
Carrot (baby or gourmet)	65-70 days after seeding	grow in well in sandy soil, but not in clay		full sun to part shade, under- story crop in hot location		thin to 1-2 " apart	weeding	high in warm weather	water deeply
Cucumber	50-70 days after seeding	add compost/ manure after germination	side dress w/compost	full sun	trellis vines	14-18" between plants		high, but needs good drainage	keep soil moist after fruit set
Eggplant	75-100 days after seeding	add compost/ manure after germination	side dress w/compost	full sun		1 plant/ container			
Lettuce (Romaine or leaf)	75-80 d. (less for baby)	needs P		part shade		4-6" btw plants, harvest basal leaves	weeding		



Market Gardening: A Start Up Guide

A Publication of ATTRA—National Sustainable Agriculture Information Service • 1-800-346-9140 • www.attra.ncat.org

By Janet Bachmann
NCAT Agriculture
Specialist
Updated May 2009

Market gardening involves the intense production of high-value crops from just a few acres and gives farmers the potential to increase their income. Market gardening is also of interest to people considering agriculture as an alternative lifestyle. This publication provides an overview of issues you need to be aware of as you consider starting market gardening and suggests helpful resources.

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Photo by Edwin Remsberg, USDA/CSREES.

Introduction

Market gardening is the commercial production of vegetables, fruits, flowers and other plants on a scale larger than a home garden, yet small enough that many of the principles of gardening are applicable. The goal, as with all farm enterprises, is to run the operation as a business and to make a profit. Market gardening is often oriented toward local markets, although production for shipping to more distant markets is also possible.

Business plan

Starting any business demands an investment of time and money. When you invest in your own business, be it market gardening or something else, a business plan will help ensure success. Developing your business plan helps you define your business, create a road map for operations, set goals, judge progress, make adjustments and satisfy a lender's request for a written explanation of how a loan will be used. A basic business plan includes:

ATTRA—National Sustainable Agriculture Information Service (www.ncat.attra.org) is managed by the National Center for Appropriate Technology (NCAT) and is funded under a grant from the United States Department of Agriculture's Rural Business-Cooperative Service. Visit the NCAT Web site (www.ncat.org/sarc_current.php) for more information on our sustainable agriculture projects.



Related ATTRA Publications

Direct Marketing

Community-Supported Agriculture

Farmers' Markets: Marketing and Business Guide

Entertainment Farming and Agri-Tourism

Postharvest Handling of Fruits and Vegetables

Resource Guide to Organic and Sustainable Vegetable Production

Scheduling Vegetable Plantings for Continuous Harvest

Season Extension Techniques for Market Gardeners

Selling to Restaurants

Specialty Cut Flower Production and Marketing

What? Describe your product or service

Why? Describe the need for your product or service

Who? Describe your customer

When? Draw a timeline and list all the tasks you need to accomplish

Where? Describe the location of your business

How? Describe equipment, materials and supplies you will use in your market garden and how you will finance your market garden

The 280-page publication *Building a Sustainable Business: A Guide to Developing a Business Plan for Farms and Rural Businesses* is an excellent tool for business planning. Developed by the Minnesota Institute for Sustainable Agriculture in St. Paul, Minn., and co-published by the Sustainable Agriculture Network, the book helps people involved with commercial alternative and sustainable agriculture create profitable businesses. The book contains sample and blank worksheets that help you learn how to set goals, research processing alternatives, determine potential markets and evaluate financing options to create a business plan. See the **Further resources** section at the end of this publication for information on how to purchase this book.

The book *Sustainable Vegetable Production from Start-Up to Market*, published in 1999 by University of Vermont vegetable specialist Vernon Grubinger, has an outline for a basic five-part business plan. See the **Further resources** section for information on purchasing this book. The ATTRA publication *Agricultural Business Planning Templates and Resources* lists additional resources, primarily Web site links. You can access it at www.attra.ncat.org or call 1-800-346-9140 for a copy.

Choosing markets

You need to develop a focused marketing plan before planting any crops. A marketing plan helps, but does not guarantee, that most of what you plant will be sold and can

help eliminate wasted time, space, produce and money. Many market gardeners try to maximize their income by selling directly to consumers and bypassing wholesalers and other middlemen. Tailgate markets, farmers' markets, roadside and on-farm stands, pick-your-own operations and subscription marketing are common direct-marketing strategies. Sales to restaurants, institutions and schools and grocery stores are common wholesale marketing strategies. More in-depth details are provided in other ATTRA publications. Most market gardeners use several outlets. Diversity in marketing, as well as diversity in planting, is a cornerstone of stability.

If you choose a wholesale market, you will not be able to charge retail prices, but your labor cost for marketing may be reduced. The case study summarized below points out that price premiums at farmers' markets are not pure profit and less-costly wholesale marketing produced the highest profits.

A California case study

When comparing markets, be sure to compare the costs as well as the returns. If you sell wholesale, you will not get the price premiums expected at a farmers' market, but your labor cost for marketing will be lower.

A recent case study in California compared marketing costs of three farms selling by wholesale, community-supported agriculture and farmers' market methods. All three farms were well-established, diversified organic growers in northern California. One farm was small, with 20 acres and two full-time employees; one medium, with 70 acres and seven employees; and one larger, with 240 acres and 30 employees.

Labor was the highest marketing expense for all the farms. At the small farm, labor was 77 percent of all marketing costs, ranging from 67 percent for wholesale marketing methods to 82 percent for farmers' markets. Farmers' markets generated the lowest net revenue return for all three growers, while wholesale provided the highest net return for all. The study shows that price premiums at farmers' markets are not pure profit. (Hardesty, 2008).



Tailgate marketing. Photo courtesy of UM Food Services.

Tailgate marketing is one of the simplest forms of direct marketing. It involves parking a vehicle loaded with produce on a road or street with the hope that people will stop and purchase the produce. This is commonly used for selling in-season regional produce. This method takes very little investment and can be set up on short notice. Check with your city government first if you plan to set up inside a city. Some cities have regulations governing transient vendors.

Farmers' markets are an excellent place for a beginning market gardener to sell their crop. Farmers' markets do not demand that a vendor bring a consistent supply of high-quality produce every market day, although that is the goal. If you have less-than-perfect tomatoes, you may be able to sell them as canners at a reduced price. A farmers' market is a wonderful place to meet people and develop steady customers, which can lead to additional marketing channels. Disadvantages include the need to spend time away from the farm and the possibility of having produce left over at the end of the market. The ATTRA publication *Farmers' Markets* offers more information and resources about establishing, promoting and being successful at a farmers' market.

On-farm marketing strategies include roadside or farm stands and pick-your-own arrangements. On-farm marketing strategies are often successful because pick-your-own customers who come for the enjoyment of spending time in the field will often also



Farmers' Market. Photo by Jim Lukens.

purchase harvested crops. Innovative farmers have found that on-farm entertainment, like animals to pet or pumpkins to carve, can be profitable additions to on-farm markets. For these marketing methods, a mower may be your most important piece of equipment since you will need to keep the farm landscape neat to attract customers. See the ATTRA publication *Entertainment Farming and Agri-Tourism* for more information about on-farm selling.

Subscription marketing is a strategy that continues to gain interest and has benefited by the use of the Internet. Community supported agriculture (CSA) is one type of subscription marketing that involves providing subscribers with a weekly basket of seasonal produce, flowers or



Farm stand. Photo by Maggie Hoback, courtesy of www.fullcirclefarm.com.



Community Supported Agriculture (CSA) Bivalve MD. Photo by Edwin Remsburg, USDA/CSREES.

livestock products. The subscribers pay at the beginning of the season for part of or their entire share of the farmer's planned production. This eliminates the problem of covering up-front production costs at the beginning of the season and guarantees a market. The challenge for the grower is to have a consistent and continuous supply of popular vegetables throughout the growing season. It is helpful to survey the customers or members about their preferences before planting. Refer to ATTRA's publication *Community Supported Agriculture* for more information.

Restaurants that are interested in serving fresh, locally grown produce can be a good market. Chefs or restaurant owners are very busy people. Ask the chefs what day and hour is the best time to call to find out what produce they need, and then be consistent about calling at that time every week. You can also find out when to make deliveries. Chefs appreciate the opportunity to tell you what they can use or would like to try. ATTRA's *Selling to Restaurants* has more information about selling to chefs, as does Diane Green's *Selling Produce to Restaurants: A Marketing Guide for Small Growers*, which is listed in the **Further resources** section.

Grocery and natural food stores may be one of the most difficult markets to break into for small-scale growers, but as interest in locally grown food increases, some stores are looking for ways to make this easier. If you want to sell to retailers, remember that they need consistently available and high-quality products. Have a sample of your product with you when you visit the store and know your selling price for the product.

A number of farm-to-school programs across the country make schools and institutions another market for small-scale growers. Food service departments at schools across the country are joining forces with concerned parents, teachers, community activists and farmers to provide students with healthy meals while simultaneously supporting small farmers in their region. Check to see if a farm-to-school program exists in your community. *Healthy Farms, Healthy Kids: Evaluating the Barriers and Opportunities for Farm-to-School Programs*, a campaign started by the Community Food Security Coalition, examines seven farm-to-school projects from around the country and provides plenty of information to start a farm-to-school program. See the **Further resources** section for information on how to find the *Healthy Farms, Healthy Kids* publication. Also useful is the ATTRA publication *Bringing Local Food to Local Institutions: A Resource Guide for Farm-to-School and Farm-to-Institution Programs*.

Market gardeners can use the Internet to transact business or distribute information about farms and products. *How to Direct Market Farm Products on the Internet*, a U.S. Department of Agriculture Agricultural Marketing Service publication, discusses what to consider before using the Internet as a marketing tool and provides examples of farmers' experiences, as well as links to more information. *Using the Internet to Get Customers* is available from the Southern Sustainable Agriculture Working Group. See the **Further resources** section for information on how to find these publications.

Learning production and marketing techniques

Apprenticing with an experienced market gardener is one of the best ways to learn sound techniques. If that opportunity isn't available, you can attend workshops and conferences, visit with other market growers, read industry materials, watch videos and experiment. State fruit and vegetable grower organizations, sustainable agriculture and organic grower groups and regional and national organizations host conferences, trade shows, workshops and field days where a wealth of information is shared. A few of these organizations, workshops and educational materials are listed in the **Further resources** section.

The Cooperative Extension System is an excellent source of bulletins on production basics for most crops. The service may be able to provide on-site consultation if you have production questions. Check calendars in trade magazines and the ATTRA online calendar at www.attra.ncat.org/calendar for conference postings. See ATTRA's Web site, www.attra.ncat.org, for current publications on soil fertility management; season extension techniques; organic production of specific crops; postharvest handling; and insect pest, weed and disease management.

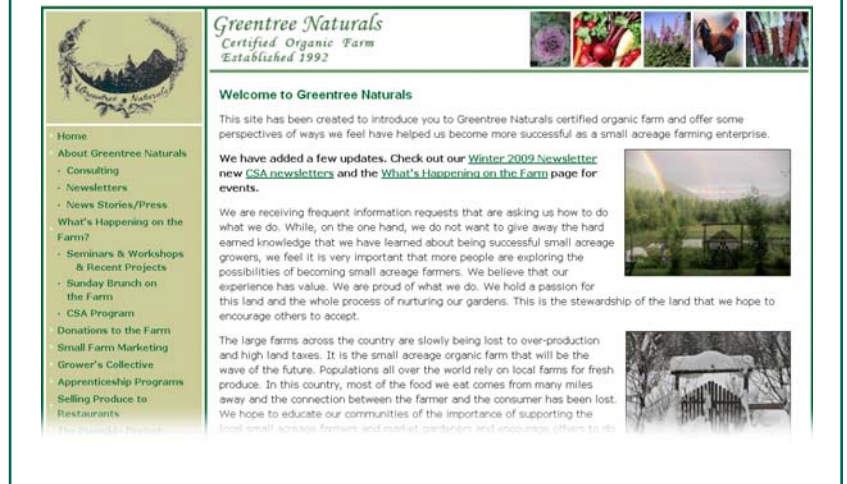
The books listed below are all highly recommended by those who have used them. Which one may be the most useful to you on a day-to-day basis depends on your scale of production. See the **Further resources** section for ordering information.

Market Farming Success was written by Lynn Byczynski, editor and publisher of the journal *Growing for Market*. The advice in this book comes from the personal experience of the author and her husband, Dan Nagengast, as market growers in eastern Kansas, as well as interviews with many other growers around the country. The book is intended to help those who are or want to be in the business of growing and selling food, flowers, herbs or plants create a profitable and efficient business. *Market Farming Success* identifies the key areas that usually hamper beginners and shows how to avoid

A green restaurant supplier

Greentree Naturals, a certified-organic farm in Sandpoint, Idaho, supplies a number of local restaurants. Diane Green and her husband, Thom Sadoski, created www.greentreenaturals.com to let people know about their products, workshops and projects. The Web site also gives Green and Sadoski a way to answer questions from other farmers.

"We receive frequent requests asking us how to do what we do," Green explains. "While on the one hand, we do not want to give away the hard-earned knowledge that we have learned about being successful small-acreage growers, we feel it is very important that more people are exploring the possibilities of becoming farmers. We believe that our experience has value. We are proud of what we do."



those obstacles. The book discusses how much money you will need to start growing, how much money you can expect to earn, the best crops and markets, essential tools, how to keep records to maximize profits and further resources.

Eliot Coleman's *The New Organic Grower: A Master's Manual of Tools and Techniques for the Home and Market Gardener* is written for market gardeners with about 5 acres of land in vegetable crop production. Coleman, an agriculture researcher, educator and farmer, describes techniques using walking tractors, wheel hoes, multi-row dibble sticks and soil block transplants. The sections on planning, crop rotations, green manures, soil fertility, direct seeding and transplants are inspiring. Coleman includes season extension techniques in this book and authored additional books on this topic, including *Four Season Harvest* and *The Winter Harvest Manual*.

Sustainable Vegetable Production from Start-up to Market was written by Vern Grubinger, a vegetable and berry specialist for University of Vermont Extension and director of the UVM Center for Sustainable Agriculture. The book is aimed at aspiring and beginning farmers. The book introduces the full range of processes for moderate-scale vegetable production using ecological practices that minimize the need for synthetic inputs and maximize conservation of resources. The book provides practical information on essential matters like selecting a farm site; planning and recordkeeping; marketing options; and systems for starting, planting, protecting and harvesting crops. The book's

final chapter profiles the experiences of 19 vegetable growers, focusing on individual crops, and provides each grower's budget for these crops.

How to Grow More Vegetables: And Fruits, Nuts, Berries, Grains, and Other Crops Than You Ever Thought Possible on Less Land Than You Can Imagine by John Jeavons details biointensive gardening techniques. The book emphasizes the use of hand tools, raised bed production, intensive spacing, companion planting and organic fertility management. The planning charts are aimed at helping families provide for their own food needs, but can be adapted for use by market gardeners as well.

Table 1. Estimated equipment needs for various sizes of vegetable farms.

Scale	Seed starting	Power source and tillage	Direct seeding	Equipment	Cultivation	Harvesting	Post-harvest handling	Delivery
1-3 acres	small hoop house, grow lights, planting trays	rototiller or walking tractor, custom work	Earthway seeder, Cyclone seeder	Back-pack, sprayer, irrigation, tools	Wheel hoe, hand hoes, digging forks, spades	Field knives, hand boxes, buckets, carts	Bulk tank, canopy, packing containers	Pickup with topper or van
4-6 acres	1,000 sq. ft., greenhouse, cold frames, field tunnels, planting trays	35-40 hp tractor, with creeper gear, power steering, high clearance	Planet Jr. plate seeder	1-row transplanter, irrigation, more tools	Cultivating tractor (IH Super A or IH 140)	Potato digger, bed lifter, wagon, more boxes, buckets	Roller track conveyor, hand carts, walk-in cooler	Cargo van
7-10 acres	Additional cold frames, planting trays	40-60 hp tractor, chisel plow, spader	Stanhay precision belt seeder with belts	2-row transplanter, sprayer	Tool bar implements: beet knives, basket weeder	More field crates	Barrel washer, spinner, pallet jack	1 ton truck with refrigeration
20 + acres	2,000 sq. ft. greenhouse	80 hp tractor with loader bucket and forks, compost spreader	Nibex or Monosem seeder	Irrigation, bed shaper, mulch layer	Sweeps (Besserides), Buddingh finger weeders, flame weeder, potato hiller, 2nd cultivating tractor	Asa lift, harvest wagon	Wash line, larger cooler, packing shed and loading dock	Refrigerated truck

Adapted from a table distributed at Michael Fields Institute Advanced Organic Vegetable Production Workshop, 2/2001, Jefferson City, MO.

Selecting equipment

Table 1 (on the previous page) is adapted from a chart distributed to participants at an Advanced Organic Vegetable Production Workshop sponsored by the Michael Fields Agricultural Institute. The chart provides an estimate of equipment needs for market gardens of various sizes. The publication *Grower to grower: Creating a livelihood on a fresh market vegetable farm* also provides information on equipment options for different sizes of farms (Hendrickson, 2005). Please keep in mind that your own needs will differ. You may be able to adapt machinery that you already have or you may be able to buy used machinery. If you are just starting out with a small amount of land, it may be more economical to purchase transplants than to build a greenhouse and grow your own. It may make sense to have primary tillage done by someone with a large tractor rather than purchase a tractor for this purpose.

Depending on your location and choice of crops, irrigation is a must for consistent and high-quality production, even on a scale of less than an acre. Drip or trickle irrigation is becoming the method of choice for many fruit, vegetable and flower growers. Grubinger's book provides a summary of overhead sprinkle and drip or trickle irrigation systems. Byczynski's book also

Tools of the trade

It is possible to operate a market garden of less than an acre with little more than a shovel, rake, hoe and garden hose. However, most serious market gardeners acquire labor-saving tools such as walk-behind rototillers, mowers, small greenhouses and small refrigerator units. Some growers, especially those farming more than an acre, use small tractors with a limited array of implements.

Experienced market gardeners advise beginning growers to first purchase equipment that will support the back end of their operations. A small walk-in cooler to maintain high product quality or an irrigation system to assure consistent yields and quality might be more important early purchases than a tractor (Hendrickson, 2005).

explains how to set up a drip system. Your local extension office can supply detailed bulletins. An irrigation specialist who will work with you to design a system to meet your needs is also helpful.

Planning and recordkeeping

Recordkeeping may be one of the most difficult tasks for market gardeners, but good records are critical if you want to know which crops are profitable. Market gardeners need records to fine-tune planting, cultivation, pest management and harvest schedules. Records help answer questions about labor, equipment and capital needs, and are valuable when developing business plans.

Alex Hitt of Peregrine Farm in Graham, N.C., keeps extensive records. The records include planned and actual data for what crops he plants, where crops are planted in the field and when Hitt plants the crops. He keeps a harvest record and a crop rotation record. Hitt tallies the produce he brings to farmers' markets, charts selling prices and notes what doesn't sell. In addition, he keeps track of farm expenses and income

Table 2. Peregrine Farm 10-year rotation

	Spring	Summer	Fall
Year 1	Tomatoes & leeks (half no-till)		Oats with crimson clover
Year 2	Cool season flowers	Sudangrass with soybeans	Oats with crimson clover
Year 3	Spring lettuce	Summer flowers	Rye with hairy vetch
Year 4	No-till squash		Fall-planted flowers
Year 5	Over-wintered flowers	Sudangrass with soybeans	Rye with hairy vetch
Year 6	Peppers (half no-till)		Wheat with crimson clover
Year 7	Summer flowers		Oats with crimson clover
Year 8	Mixed spring vegetables	Cowpeas	Fall-planted flowers
Year 9	Over-wintered flowers	Sudangrass with soybeans	Oats with crimson clover
Year 10	Summer flowers		Wheat with hairy vetch

and records daily activities, including time spent on each farm task. A sample planting record is included on a CD titled *Organic Vegetable Production and Marketing in the South with Alex Hitt of Peregrine Farm*, produced by the Southern Sustainable Agriculture Working Group. See the **Further resources** section for ordering information.

Labor

The size of your operation and the crops, markets, and equipment you choose will determine the amount of labor needed. Two of the growers profiled in this publication have decided that they do not want to hire outside help and planned their production and marketing accordingly.

Many market gardeners, however, will need help. In an advanced organic vegetable production workshop offered by the Michael Fields Agricultural Institute, Richard DeWilde of Harmony Valley Farm explains how to manage labor so crews will be happy and productive. DeWilde's operation is one described in the grower profiles at the end of this publication.

DeWilde emphasizes that it is important to be clear about your employee expectations and operating procedures. He does this by meeting regularly with his employees and using an employee manual. An employee manual details farm standards and expectations. For example, it might tell people what to do with trash and include a Friday night checklist to ensure that supplies and equipment are properly stored at the end of the week. Employees do not work on Saturday or Sunday.

On Monday morning DeWilde meets with his crew in the packing shed. He makes the day and week manageable by writing down all that needs to be accomplished on two dry erase boards. One board provides information about tasks planned for the entire week. On the other board, De Wilde posts tasks for the day with assignments for who will do each task. Past records show how long it should take to do each task. This information is critical for determining assignments.

Separate task sheets list supplies needed for each task. For example, if floating row covers need to be laid, the task sheet will include shovels, markers and marking pens.

Harmony Valley Farm commits to providing full-time jobs. A list of rainy day tasks and extra chores is on hand to ensure that employees always have something useful to do.

DeWilde emphasizes that it is important for employers to be knowledgeable about government regulations, including field sanitation, drinking water, worker protection and safety regulations. A resource for learning about government regulations is Neil D. Hamilton's *The Legal Guide for Direct Farm Marketing*. The book includes a chapter on labor and employment. See the **Further resources** section for ordering information.

Food safety

Changing lifestyles and a growing interest among consumers in fresh, nutritious food has created an increase in produce consumption. Along with this increase, there has been an increase in the number of food-borne illness outbreaks associated with fresh fruits and vegetables. An occurrence can cause irreparable damage to a business, both legally and from the negative effects on its reputation (Cuellar, 2001).

Currently, there are no mandatory rules for the safe growing and packing of fruits and vegetables, except for those regulating water and pesticide residues under the surveillance of the Environmental Protection Agency. In 1998, however, the EPA published the *Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables*, comprising a set of Good Agricultural Practices. Although the practices are optional, many growers incorporate them into their operations. Extension offices in a number of states provide bulletins outlining safe growing and packing practices. Cornell University compiled a number of educational materials in English and other languages. The National GAPs Education Materials can be found at the Web site www.gaps.cornell.edu/educationalmaterials.html. Kansas State University published *Food*A*Syst*, a

Past records show how long it should take to do each task. This information is critical for determining assignments.

handbook to help address food safety and environmental concerns. You can find the third chapter, *Growing Vegetables, Fruits and Produce*, online at www.oznet.ksu.edu/library/fntr2/foodasyst/foodasys.pdf. The University of California's *Good Agricultural Practices: A Self Audit for Growers and Handlers* is online at <http://ucce.ucdavis.edu/files/filelibrary/5453/4362.pdf>.

Agricultural insurance

According to the Washington State Department of Agriculture, insurance is one of the most overlooked pieces of running a farm business. In today's litigious culture, it is wise to have adequate coverage for all your farm activities. Insurance coverage is available for nearly any activity on your farm, but the cost of coverage may not be economically viable. Shop around for the insurance that best suits your needs and balance the coverage into your farm business plan.

If your farming operation is very small, you may be able to simply add coverage to your homeowner's policy. Larger operations may require a farm policy that includes property coverage as well as liability coverage for physical injury and ingested food products. A farm policy can also cover a roadside stand whether or not it is on your property and may be extended by endorsement to cover a farmers' market stand. Farms that process foods or sell primarily flowers or other non-edibles may require a commercial general liability policy (WSDA, 2006).

Visit the Washington State Department of Agriculture Web site at http://agr.wa.gov/Marketing/SmallFarm/Insurance_Risk_Management.htm#Insurance for more information.

The Pennsylvania State University bulletin *Agricultural Business Insurance* discusses the different types of insurance you should consider as part of your risk management strategy. Agricultural business insurances include general liability, product liability, business property, workers compensation, vehicle and crop insurance and more. The bulletin is available online at <http://agalternatives.aers.psu.edu/>

[Publications/AgBusinessInsurPM7.pdf](#) or see the **Further resources** section for information on obtaining a print copy.

A very readable discussion on insurance is in Lynn Byczynski's *Market Farming Success*. She advises that your best bet in finding what you need is to sit down with an independent agent and explain your business thoroughly. Another excellent resource on this issue is Neil Hamilton's *The Legal Guide for Direct Farm Marketing*. Both books are listed in the **Further resources** section.

Organic market gardening

Some market gardeners grow their crops organically. The motivations vary. Some market gardeners think it is the socially and environmentally responsible thing to do. Some are motivated by economic benefits. Organically grown produce typically commands higher prices in the marketplace. Growers who sell through CSAs or use other forms of relationship marketing sometimes find that their customers expect and demand organic produce. There is a long history that equates organic farming with fresh, whole foods.

The production and marketing of organic foods is subject to federal regulation. Organic production is defined in legal terms and use of the term organic is controlled. You must be certified by the USDA to market your products as organic unless your annual sales of organic products are less than \$5,000. ATTRA has numerous publications that address organic matters. See ATTRA's *Guide to Organic Publications* for more information.

Grower profiles

To give you additional ideas and inspiration, several market gardeners from different parts of the United States agreed to share information about their operations. Alex and Betsy Hitt are featured in the Sustainable Agriculture Network publication *Building Soils for Better Crops, 2nd Ed.* and *The New American Farmer*. Richard DeWilde and Linda Halley are also featured in *The New American Farmer*.

In today's litigious culture, it is wise to have adequate coverage for all your farm activities.

It is interesting to note that although each operation is unique, all have a number of things in common. These include:

- Diversity of crops
- Diversity of marketing strategies
- Cover crops grown for soil building
- Detailed recordkeeping systems
- Willingness to share knowledge and ideas with others

Peregrine Farm, Alex and Betsy Hitt, Graham, N.C.

Alex and Betsy Hitt began market gardening on their 26-acre farm near Chapel Hill, N.C. almost 20 years ago. They grow organic vegetables and specialty cut flowers on 5 acres and have a quarter of an acre in highbush blueberries. The Hitts sell primarily to local farmers' markets, but have also sold to restaurants and stores.

"Our original goals," Alex Hitt said, "were to make a living on this piece of ground while taking the best care of it that we could." For the Hitts, making a living doing work they enjoy and finding a scale that allows them to do most of it themselves are key aspects of sustainability. Their crop mix and markets have changed over the years, as they continue to evaluate the success of each operation and its place within the whole system.

When the horse stable down the road went out of business, it forced the Hitts to re-evaluate their farm fertility program. Without this source of free manure, the Hitts created an elaborate rotation that includes both winter and summer cover crops to supply organic matter and nitrogen, prevent erosion and crowd out weeds.

"We designed a rotation so that cover crops play a clear role," Hitt said. "Many times, where other growers might say, 'I need to grow a cash crop,' we'll grow a cover crop anyway."

The farm stays profitable thanks to a marketing plan that takes full advantage of

their location near Chapel Hill, home to the University of North Carolina. More unusual produce like leafy greens, leeks and rapini find a home in restaurants, and sell well alongside their most profitable lettuce, tomato, pepper and flower crops at area farmers' markets.

A year in the Hitts' rotation may include a cool-season cash crop and a summer cover crop like soybeans and sudangrass followed by a fall cash crop and then a winter cover.

"We have made a conscious decision in our rotation design to always have cover crops," Alex Hitt said. "We have to. It's the primary source for all of our fertility. If we can, we'll have two covers on the same piece of ground in the same year."

While other farmers grow beans, corn or another profitable annual vegetable in the summer after a spring crop, the Hitts don't hesitate to take the land out of production. Instead, Alex Hitt said, their commitment to building organic matter in the soil yields important payoffs. The farm remains essentially free of soilborne diseases, which they attribute to "so much competition and diversity" in the soil. And, despite farming on a 5-percent slope, they see little or no erosion.

The Hitt's 10-year rotation plan is on page 7. You can learn more with the *CD Organic Vegetable Production and Marketing in the South with Alex Hitt of Peregrine Farm*, available from the Southern Sustainable Agriculture Working Group. See the **Further resources** section for ordering information.

Beech Grove Farm, Ann and Eric Nordell, Trout Run, Pa.

Neither Ann nor Eric grew up on a farm, but both gained experiences on other farms during and after college before they bought Beech Grove Farm, their small farm near Trout Run, Pa. In this area with steep, rugged terrain and a relatively short growing season, they had three goals:

- Remain debt-free

The Hitts created an elaborate rotation that includes both winter and summer cover crops to supply organic matter and nitrogen, prevent erosion and crowd out weeds.

- Keep the farm a two-person operation
- Depend on the internal resources of the farm as much as possible.

Of the 90 acres on the farm, 30 are wooded. Six are cultivated for the market garden. The remainder, excluding the homestead and house garden, is left in pasture. They use draft horses and low-cost implements for cultivation and tillage and have the 6-acre plot divided into half-acre strips of 20 yards by 120 yards, which the Nordells find to be a good size for working with horses and by hand.

Because the farm is distant from major markets, the Nordells first chose crops that can be sold wholesale, like flowers and medicinal herbs for drying and root vegetables. As the couple became known in the area, they were approached by restaurant buyers to supply cool-season and specialty items. By 1998, they were selling to 10 fine restaurants in the area and at the Williamsport farmers' market. Income from wholesale markets is now only 10 percent of their total income.

For the Nordells, as for all market gardeners, weeds presented a major challenge. They adapted a traditional field crop rotation system of corn, oats, wheat, grass and legume sod used in the Midwest and Pennsylvania to a rotation that includes vegetables, cover crops and a summer fallow. The half-acre strips are managed so that 3 acres are in crops and 3 acres are in fallow or cover crops. Over the years, the Nordells reduced the fallow period to six weeks or less as the weed population has diminished.

The Nordells offer a video of a slide presentation made at the 1996 Pennsylvania Association for Sustainable Agriculture Conference that explains their controlled rotational cover cropping in the bio-extensive market garden system. The Nordells also collected copies of the articles they've written about rotation, cultivation, growing onions, using pigs to turn compost, designing a barn for animals and for compost production and more. The Nordells also have a new weed

management publication, *Weed the Soil Not the Crop*, available for \$10 plus \$3 shipping and handling. Order these directly from them at 3410 Rt. 184, Trout Run, PA 17771. You can read more at www.newfarm.org/features/1204/nordell/index.shtml.

Harmony Valley Farm, Richard DeWilde and Linda Halley, Viroqua, Wis.

Richard DeWilde has farmed for most of his life. He moved to Harmony Valley Farm in 1984 after his farm in Minnesota was paved over by urban sprawl. Linda joined him there in 1990. The DeWildes grow vegetables, fruits and herbs on 70 acres and have pasture, hay and a few Angus steers on 220 acres. They sell produce wholesale at the Dane County Farmers' Market in Madison, and through a 500-member CSA. DeWilde handles this scale of operation by hiring labor, becoming highly mechanized and through careful management.

DeWilde notes that his wholesale markets have been the most profitable, and CSA the least. The time needed for management makes the difference. The wholesale market is the least diverse. The moneymaking crops are turnips and daikon radishes. A CSA market demands a tremendous diversity of crops and a complexity of management needed for market.

Soil building is done with cover crops, compost and additional micronutrients as needed. Favored cover crops are sweet clover, vetch, rye, oats and peas. Seeds for these are available locally and are reasonably priced. The residue is chopped into the top 1 or 2 inches of soil with a rotovator.

DeWilde and Halley have experimented with many ingredients for making compost and have been pleased with dairy manure and cornstalks, which are readily available and have a good carbon-to-nitrogen ratio. The compost is made in windrows, turned with an old wildcat turner pulled by an International tractor equipped with a hydrostatic drive so that it can move slowly. Finished compost is spread on fields at a rate of 10 to 15 tons per acre.

A CSA market demands a tremendous diversity of crops.

One strategy for insect pest management on Harmony Valley Farm is to provide permanent habitat for natural predators and parasites. Refuge strips in the fields are made up of plants that attract and harbor beneficial insects and birds. A number of these plants can also be cut and sold as flowers or woody ornamentals.

Richard says his goal is “to develop an organic farming curriculum, complete with slides. My time and focus could be put into a Harmony Valley Farm operating manual. It would deal with communication, employee training and recordkeeping. Who knows? Maybe I would retire and do training seminars.”

Halley adds, “We really do have clear family goals: to continue to learn new ways to do things on the farm and communicate those things.”

Thompson Farms, Larry Thompson, Boring, Ore.

Oregon farmer Larry Thompson has a long history of using innovative, sustainable practices to grow his array of berries and vegetables. He also works closely with the fast-growing community of Damascus to develop policies that help farmers hold onto their operations as urban boundaries grow around them. Thompson Farms has 140 acres in strawberries, raspberries, cauliflower, broccoli and other crops. Produce is sold at farmers’ markets and farm stands; one in a new location just outside a hospital where patients, nurses and staff benefit from his healthy fruits and vegetables.

Thompson’s parents, Victor and Betty, began raising raspberries, strawberries and broccoli in the rolling hills southeast of Portland in 1947. Thompson’s parents sold their produce to local processors, where agents for canneries always set the purchase price. In 1983, Thompson took over operating the farm and sought more profitable places to sell his produce.

After Thompson started working on the 140-acre farm, he quickly learned that selling to canneries failed to cover production expenses. The family opened their farm to the local suburban community. Thompson started offering pick-your-own berries and selling the fruit at a stand he built at the farm. Strawberry sales were so strong that Thompson decided to plant new varieties to extend the season.

The Thompsons soon attracted a loyal following, primarily from Portland, which is 20 miles away. The family started selling at area farmers’ markets, too. The family and 23 employees raise 43 crops and sell them at six markets and two farm stands and through on-farm activities. For Thompson, profitability means that each year he earns more money than he spends. “I reach that level consistently,” he said.

Thompson makes sure he earns a profit. He calculates the cost of planting, raising and harvesting each crop, and then charges his customers double that. His most profitable crop is strawberries. Retaining different marketing channels gives Thompson a chance to cross-promote.

Thompson is a dedicated advocate of crop rotations and planting a succession of flowering species to control pests without pesticides. He relies on cover crops to control weeds and provide habitat for beneficial insects. Thompson allows native grasses and dandelions to grow between his berry rows. The dandelion blossoms attract bees, which are efficient berry pollinators. The mixed vegetation provides an alluring habitat that, along with flowering fruit and vegetable plants, draws insects that prey on pests. Late in the year, Thompson doesn’t mow broccoli stubble. Instead, he lets side shoots bloom, creating a long-term nectar source for bees into early winter. Thompson Farms sits on erodible soils and runoff used to be a major problem. But thanks to the cover crops and other soil cover, now virtually no soil leaves the farm.

Thompson makes sure he earns a profit. He calculates the cost of planting, raising and harvesting each crop, and then charges his customers double that.

Thompson won the Sustainable Agriculture Research and Education's 2008 Patrick Madden Award for Sustainable Agriculture. Many call him a pro at relationship marketing, or forming bonds with customers who see a value in local produce raised with few chemicals. Thompson regularly offers tours to students, other farmers, researchers and visiting international delegations to show

off his holistic pest management strategies and bounty of colorful crops. As a result, the farm attracts people by the busload for educational seasonal events.

"Instead of seeing my farm as a secluded hideaway, I am getting the community involved, bringing them to see our principles in action," Thompson said (USDA CSREES, 2008).

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Further resources

Books

Corum, Vance et al. 2001. *The New Farmer's Market: Farm-Fresh Ideas for Producers, Managers and Communities*. New World Publishing. 272 p. Available for \$24.95 plus \$3.95 shipping and handling from:
SAN Publications
Hills Building, Room 10
University of Vermont
Burlington, VT 05405-0082
(802) 656-0484
sanpubs@uvm.edu

Covers the latest tips and trends from leading sellers, managers and market planners all over the country, including the hottest products to grow and sell as well as how best to display and merchandise your products, set prices and run a friendly, profitable business. The second half of the book, written for market managers and city planners, offers ideas about how to use farmers' markets as a springboard to foster community support for sustainable and locally grown foods. List of additional resources.

Hamilton, Neil D. 1999. *The Legal Guide to Direct Farm Marketing*. Drake University. 235 p. To request a copy, contact:
Karla Westberg
(515) 271-2947
Karla.westberg@drake.edu

Covers questions about liability, insurance coverage, labor laws, advertising claims, zoning, pesticide drift, inspections and food safety issues.

Green, Diane. 2005. *Selling Produce to Restaurants: A Marketing Guide for Small Growers*. 95 p.
greentree@coldreams.com
www.greentreenaturals.com/selling_book.htm

Available for \$12.95 plus \$3.95 shipping from:

Greentree Naturals
2003 Rapid Lightning Road
Sandpoint, ID 83864
(208) 263-8957

The author is a certified organic grower in Idaho who markets through restaurants, CSA subscriptions and a farmers' market.

DiGiacomo, Gigi, Robert King, and Dale Nordquist. 2003. *Building a Sustainable Business: A Guide to Developing a Business Plan for Farms and Rural Businesses*. Minnesota Institute for Sustainable Agriculture. 280 p. Printed copies are available for \$14 plus \$3.95 shipping and handling from:
SAN Publications
Hills Building, Room 10
University of Vermont
Burlington, VT 05405-0082
(802) 656-0484
sanpubs@uvm.edu

You can also download the publication from www.sare.org/publications/business/business.pdf.

Byczynski, Lynn. 2006. *Market Farming Success*. Fairplain Publications, Lawrence, KS. 138 p.
Available from:
Growing for Market
PO Box 3747
Lawrence, KS 66046
1-800-307-8949
www.growingformarket.com

Coleman, Eliot. 1995. *The New Organic Growers: A Master's Manual of Tools and Techniques for the Home and Market Gardener*, 2nd ed. Chelsea Green Publishing Company. 340 p.

Coleman, Eliot. 1998. *The Winter Harvest Manual*. 63 p. Available for \$15, including postage, from:
Four Seasons Farm
609 Weir Cove Road
Harborside, ME 04642

A supplement to The New Organic Grower, this manual records recent experience in planning, carrying out and fine tuning a fresh vegetable production and marketing operation on the back side of the calendar.

Grubinger, Vernon. 1999. *Sustainable Vegetable Production from Start-Up to Market*. NRAES-104. 270 p. Available for \$38 plus \$6 for shipping and handling from:
NRAES, Cooperative Extension
152 Riley-Robb Hall
Ithaca, NY 14853-5701
(607) 255-7654
(607) 254-8770 FAX
nraes@cornell.edu
www.nraes.org/publications/nraes104.html

Jeavons, John. 2002. *How to Grow More Vegetables*, 6th ed. Ten Speed Press. 276 p.

Magdoff, Fred and H. van Es. 2000. *Building Soils for Better Crops* 2nd ed. Available for \$19.95 plus \$3.95 shipping and handling from:
SAN Publications
PO Box 753
Waldorf, MD 20604-0753
(301) 374-9696
sanpubs@sare.org
www.sare.org
You can also download a free copy at www.sare.org/publications/bsbc/bsbc.pdf.

Valerie Berton, editor. 2005. *The New American Farmer*. 200 p. Available for \$16.95 plus \$5.95 shipping and handling from:
Sustainable Agriculture Network
10300 Baltimore Ave., Bldg. 046
Beltsville, MD 20705-2350
(301) 504-5236
(301) 504-5207 FAX
san_assoc@sare.org
You can also download a free copy at www.nrcs.usda.gov/NEWS/thisweek/2005/062205/susag18.html.

Bulletins or reports

Azuma, Andrea Misako and Andrew Fisher. 2001. *Healthy Farms, Healthy Kids*. CFS Coalition. 64 p. Available for \$12 plus \$4 shipping and handling from:
Community Food Security Coalition

PO Box 209
Venice, CA 90294
(310) 822-5410
asfisher@aol.com
www.foodsecurity.org

This report documents the barriers and opportunities for school food services to purchase food directly from local farmers. Case studies and policy recommendations are included.

Klotz, Jennifer-Claire. 2002. How to Direct Market Farm Products on the Internet. USDA Agricultural Marketing Service. 50 p. For a copy, contact: USDA Agricultural Marketing Service Transportation and Marketing Programs Marketing Services Division 1400 Independence Ave., S.W. Room 2646-South Washington, DC 20250 (202) 690-0031 www.ams.usda.gov

Newenhouse, Astrid et al. 1998–2001. Work Efficiency Tip Sheets. University of Wisconsin. Available from: Healthy Farmers, Healthy Profits Project Biological Systems Engineering, UW-Madison 460 Henry Mall Madison, WI 53706 <http://bse.wisc.edu/hfhp>
A series of tip sheets on labor efficiency for vegetable and berry growers.

Periodicals

Growing for Market

Subscriptions are available from:
PO Box 3747
Lawrence, KS 66046
1-800-307-8949
www.growingformarket.com

Growing for Market is published 10 times per year. It covers growing and direct marketing vegetables, fruits, herbs, cut flowers and plants, farmers markets, Community Supported Agriculture, the local food movement, organic growing, cut flowers, and much more. Print subscriptions are \$33 per year, or 2 years for \$60. It is also available electronically.

Small Farm News

Now available online or from:
Small Farm Center
University of California
One Shields Ave.
Davis, CA 95616-8699
(530) 752-8136
sfcenter@ucdavis.edu
www.sfc.ucdavis.edu

The 12-page Small Farm News is published four times per year. It features farmer and farm advisor profiles, research articles, farm-related print and web site resources, news items, and a calendar of state, national, and international events. The newsletter is free. However, contributions to help defray expenses are encouraged. Many past newsletters contained articles on marketing produce and crafts.

Other SFC publications of possible interest include Small Farm Handbook, a guide for people interested in operating a successful small farm; Production Practices and Sample Costs, Chili Pepper, Eggplant, Lettuce, and Okra. These and more are available for free online or \$4 each for printed version.

The Packer

Target audience is primarily large-scale produce growers and wholesalers.
Subscription rates are \$79 per year. The Packer is available online in both English and Spanish from: Vance Publishing Corp.
PO Box 1415
400 Knightsbridge Pkwy.
Lincolnshire, IL 60069
(847) 634-2600
www.thepacker.com

American Vegetable Grower

Available from:
Meister Media
37733 Euclid Ave.
Willoughby, OH 44094-5992
1-800-572-7740
avg.circ@meistermedia.com
www.americanvegetablegrower.com

Monthly publication featuring production and marketing information. Annual Sourcebook provides information on state vegetable grower organizations. Also information about equipment and supplies. Print

or online. Free to qualified growers and consultants. Meister also publishes *American Fruit Grower*.

Agencies, associations and organizations

North American Direct Marketing Association
62 White Loaf Road
Southampton, MA 01073
1-888-884-9270
info@fafdma.com
www.familyfarms.com

NAFDMA is a 501(c)6 trade association whose members include farmers, farmers' market managers, extension agents, industry suppliers, government officials and others involved with agritourism, on-farm retail, farmers' markets, pick-your-own, consumer-supported agriculture and direct delivery. The organization hosts an annual conference and trade show.

Association of Specialty Cut Flower Growers
MPO Box 268
17 ½ College St.
Oberlin, OH 44074
(440) 774-2887
ascfg@oberlin.net
www.ascfg.org

*Formed in 1988, the essential goal of ASCFG is to help growers of specialty cut flowers produce a better crop. The ASCFG hosts an annual conference and trade show, regional workshops, coordinates new variety trials and publishes the *Cut Flower Quarterly*. Its members share information based on their field and marketing experience through a *Bulletin Board*.*

Southern Sustainable Agriculture Working Group
(Southern SAWG)
PO Box 1552
Fayetteville, AR 72702
(479) 251-8310
info@ssawg.org
www.ssawg.org

*This association of organizations and individuals from 13 Southern states holds the *Practical Tools and Solutions for Sustaining Family Farms Conference*, an annual January event that provides a forum to learn about sustainable farming techniques and marketing strategies, community food systems and federal farm policies and programs that promote sustainable agriculture. This event also provides producers, researchers, information providers, concerned consumers and community organizers the opportunity to build networks,*

strengthen alliances and celebrate the achievements of Southern sustainable farmers.

*Southern SAWG's video series titled *Natural Farming Systems in the South* provides an easy, economical way to take a virtual tour of some highly successful farming operations in the region. Organic vegetables and cut flowers are among the enterprises covered.*

Center for Integrated Agricultural Systems
1535 Observatory Drive
UW-Madison
Madison, WI 53706
Contact:
John Hendrickson
(608) 265-3704
jhendric@facstaff.wisc.edu
www.cias.wisc.edu/marketgrower.php

Wisconsin School for Beginning Market Growers is an intensive three-day course held in January or February. The course demonstrates what it takes to set up and run a successful market garden or small farm, including capital, management, labor and other resources. Topics include soil fertility, crop production, plant health and pest management, cover crops, equipment needs and labor considerations at different scales of operation and marketing and economics. The course is taught primarily by three growers whose farms vary in scale, cropping mix, marketing strategies and growing methods. It includes presentations and hands-on labs by University of Wisconsin faculty and other specialists.

Michael Fields Institute
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*These videos were produced by Vern Grubinger,
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Hitt, Alex. 2007. Organic Vegetable Production &
Marketing in the South with Alex Hitt of Peregrine
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*This Windows-only CD-ROM resource grew out of
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Nordell, Anne and Eric. 1996.

Available for \$10 by writing to:

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*A 52-minute video of a slide presentation by the
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Kaplan, Dan. No date. Crop Planning and Record
Keeping with MS Excel.

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Rosenzweig, Marcie. No date. Market Farm Forms:
Spreadsheet Templates for Planning and Organization
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*A discussion group that covers tools and equipment,
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Business plans

Developing a Business Plan. 2004. Agriculture Alterna-
tives. Penn State College of Agricultural Sciences Agri-
cultural Research and Cooperative Extension.

<http://agalternatives.aers.psu.edu/Publications/new>

[DevelopBusPlanPM7.pdf](#)

Building a Plan for Your Farm: Important First Steps.
2003. Jones, Rodney. Presented at the 2003 Risk and
Profit Summer Conference. [www.agmanager.info/farm-
mgt/planning/Building_a_Plan_for_Your_Farm.pdf](http://www.agmanager.info/farm-mgt/planning/Building_a_Plan_for_Your_Farm.pdf)

Notes

Market Gardening: A Start Up Guide

By Janet Bachmann
NCAT Agriculture Specialist
Updated May 2009

Holly Michels, Editor
Amy Smith, Production

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www.attra.ncat.org/attra-pub/marketgardening.html
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Chapter Three

Fuelwood

MEASURES

The most common unit of measure for fuelwood is the standard cord, which is a pile of 4 foot long pieces of wood 4 feet high and 8 feet long, with a volume of 128 cubic feet (Figure 3-1).

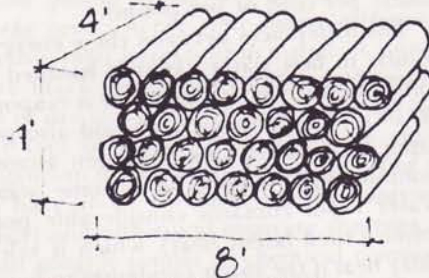


Figure 3-1. A cord of wood.

The 128 cubic foot volume includes some air between the pieces of wood. The actual volume of solid wood can range from 60 to 100 cubic feet depending on both the shape of pieces and how they are stacked. If the pieces of wood are crooked and bumpy, the air spaces will be relatively large and a cord will contain less solid wood. If straight pieces with a variety of diameters and shapes are used, much more wood can be piled into a cord if care is taken to use the smaller pieces to fill in the spaces between the larger, as in a carefully constructed stone wall (Figure 3-2).

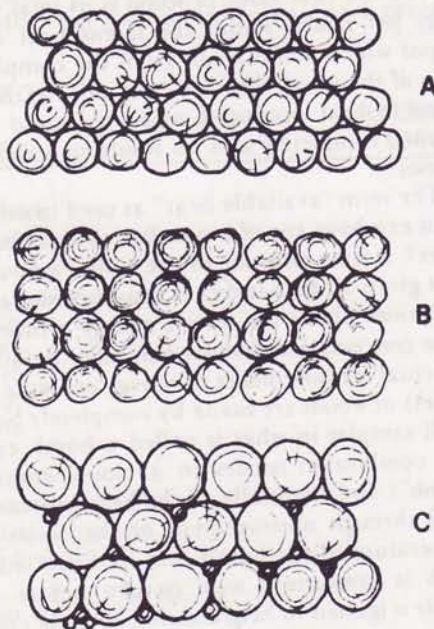


Figure 3-2. Some effects of stacking density on the amount of actual solid wood in a cord. Pattern A represents the densest packing of straight, uniform-diameter logs. Stacked as in pattern B, there are 13 percent fewer logs in a cord compared to A. With small logs filling some of the spaces in pattern A, as indicated in C, a cord contains 2.3 percent more solid wood compared to A.

A standard cord is defined to be 128 cubic foot pile of wood in 4 foot long pieces. If the pieces are cut into shorter lengths and restacked, the volume will be less for two reasons: 1) some wood is lost as sawdust. 2) more importantly, shorter pieces generally fit closer together, by an amount depending on how crooked or irregular the 4 foot pieces were. A 25 percent volume decrease is possible. After splitting the wood, the volume of the pile may also change.

A face cord (or run cord, or a rick), is the amount of wood in a pile 4 feet high and 8 feet long, period (Figure 3-3). The width of the pile (or length of the pieces) can be anything. A face cord of 2 foot long logs (a 2 foot face cord) would be a pile 4 feet x 8 feet x 2 feet. It would probably be a little more than half a standard cord because of denser packing of shorter pieces. A 4 foot face cord is exactly a standard cord.

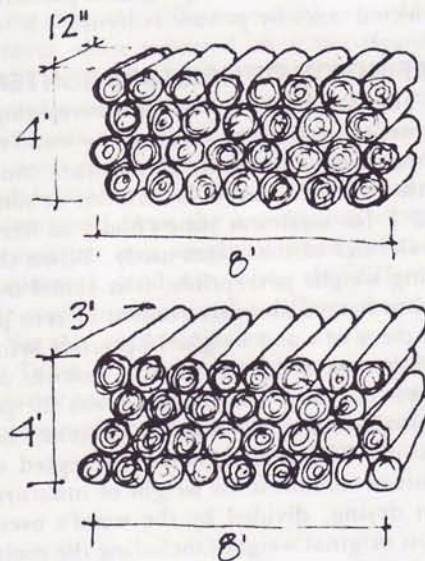


Figure 3-3. Two face cords.

SOURCES

Fuelwood can be obtained from a great variety of sources at a great range of prices. The most expensive and most convenient way to get wood is to buy it, cut to the buyer's specified length, split and "seasoned" or air dried. Prices usually fall between \$25 and \$175 per standard cord. Green wood (wood recently cut from live trees) is sometimes cheaper. A year is ample for drying (or seasoning), so if one has storage space and can buy a year in advance, one can take advantage of the lower prices some sellers offer on green wood.

Sawmill slabs and edgings are the wastes from making round, tapered trees into square, straight lumber. Some mills, particularly smaller ones, sell (and in some cases deliver) slabs and edgings at a very reasonable cost. Some people prefer these mill wastes because they do not need splitting, and they are inexpensive. However, they usually need cutting because they tend to come in long lengths (typically 8 to 16 feet). Also hardwood wastes, which some people prefer, are less common than softwood wastes. Prices, of course, may rise and availability decline, as demand grows, especially the demand for chips. Increasingly, mills sell or use all their wood wastes. Many mills burn their wastes to heat their buildings, generate electrici-

ty, and dry their lumber. The older practice of burning wastes just to make disposal easier is declining due to air pollution laws and the rising cost of energy.

If one is equipped and willing to haul wood, and to cut and split, local dumps, landfills, and construction sites can be sources of already felled and trimmed wood. Landscapers and arborists may be happy to dump their wastes at a residence. Neighbors who do their own landscaping may give away felled trees. Both electric utility and telephone companies clear trees and large branches from their overhead lines, and often the usable fuelwood is left in piles under the lines for the public. Demolition sites can be a source of very dry, and sometimes dirty, lumber. Road construction and improvement projects sometimes have felled and limbed trees which need disposal, and many state and national forests have programs permitting cutting of selected trees by private citizens.

DEFINITION OF MOISTURE CONTENT

The standard method for determining the moisture content of wood is to measure the wood's loss in weight when dried. Essentially all moisture can be driven off if the wood is placed in an oven at somewhat above 212°F for sufficient time (hours to weeks depending on the size of the pieces used). When the wood stops losing weight perceptibly, it is called oven-dry and is said to have a moisture content of zero percent. Thus if a piece of wood weighs 10 pounds before such oven drying, and 8 pounds after, 2 pounds of water were driven off, and the moisture was 20 percent of its original weight. Its "moisture content," however, is 25 percent. The most generally accepted definition of moisture content is the weight of moisture lost during oven drying, divided by the wood's oven-dry weight, not its original weight (including the moisture). Thus wood with a moisture content of 100 percent is not pure water, but half water and half dry wood. (See Appendix 2.) The moisture content of green woods is typically between 50 and 150 percent. Seasoned firewood has a moisture content of roughly 20 percent.

ENERGY CONTENT

Through experience one develops impressions of differences among the heating performances of various woods. Some people become quite particular about the wood they insist on burning. Others burn practically any wood without apparent difficulty.

Is there a difference in the amount of heat one wood will give compared to another? Different woods certainly burn with different characteristics. Wet wood is more difficult to burn. Dense woods such as apple burn for a longer time than light woods such as pine. Some wood types are easier to ignite than others, and are thus especially useful for kindling. Some produce smoke with an especially pleasing fragrance.

One of the most important characteristics of a wood is its energy content. A reading of some of the available lists can be confusing and frustrating — confusing because large discrepancies (as big as 42 percent) exist between lists concerning the energy content of a cord of a given type of wood, and frustrating because woods one may be particularly interested in may not be listed.

The confusion arises because there are a number of

different concepts relating to the energy in wood. Three common measures of energy content are called high heat value (or gross heat value), and low heat value (or net heat value), and available heat. The first two of these measures have unambiguous meanings and are commonly used by heating engineers. The third, available heat, is not a precisely defined concept and different authors have given it different meanings. The units in all cases are usually Btu's (British thermal units) per cord or per pound.

The differences between these energy measures are mostly in how water vapor is handled. All wood has some moisture in it; this water is evaporated or boiled off in a fire. Perfectly dry wood also generates water vapor as it burns; the hydrogen atoms in the wood combine with oxygen to become water molecules. Water vapor contains considerable potential energy (often called latent heat) which is released as (sensible) heat if the vapor condenses to liquid water. The amount of energy is the same as must be given to liquid water to make it boil away or evaporate and is about 1050 Btu per pound of water. In practice, when wood is burned in a stove or fireplace, not much of this latent heat becomes available for use because not much of the water vapor condenses.

The high heat value of wood is its total chemical energy per pound. It represents the amount of chemical energy released when 1 pound of wood is completely burned. Only if all the water vapor (which was evaporated or boiled off or manufactured during the combustion) condenses, does all the chemical energy become usable sensible heat.

The low heat value of wood is its total chemical energy per pound minus the latent heat in the water vapor which would result from the complete combustion of the wood. The low heat value is the amount of sensible heat produced when a pound of wood is burned completely and no resulting water vapor condenses.

The term "available heat" as used in other publications can have any of a number of meanings. In most cases¹ it is an estimate of the actual amount of useful heat given off by a stove; it thus includes arbitrary assumptions about the stove's energy efficiency. All of these concepts are discussed in more detail below.

Actual measurements of energy contents (or caloric values) of woods are made by completely burning very small samples in what is called a bomb calorimeter. The combustion occurs in a closed container (the "bomb") and essentially all the heat generated is measured through measurement of the resulting rise in temperature of the bomb and its surroundings. The bomb is pressurized with oxygen before the wood sample is ignited to help ensure complete combustion.

There are often discrepancies for the same kind of wood.² These may be due to regional, seasonal or individual tree differences, or the investigators may not have used identical species. Wood from different parts of the same tree sometimes yield slightly different values. Heartwood and sapwood have slightly different chemical compositions. Sapwood is the lighter-colored outer portion of a log or stem and heartwood is the (usually) darker-colored central portion. In a live tree, the wood cells in the sapwood are alive, and those in the heartwood are not. Earlywood (spring growth)

and latewood (summer growth) also have slightly different compositions. Wood with different proportions of these components might be expected to have different overall energy contents. Thus variations of a few percent in measured energy content for a given type of wood are probably to be expected.

Despite apparent discrepancies and problems, it is remarkable how nearly equal are the energy contents of all of the different kinds of wood. *To within a few percent, one pound of oven-dry wood of almost any kind has the same energy. The major difference between woods is their weights or densities.* A solid cubic foot of dry black locust weighs about 43 pounds; a cubic foot of dry Douglas fir weighs about 30 pounds. The cubic foot of black locust has more energy in direct proportion to its greater dry weight. The reason all woods have about the same energy content on a weight basis (and with equal moisture content) is that they are all roughly similar in chemical composition.

But there are slight chemical differences among woods, and these probably explain the differences in their energy contents. Species with large amounts of pitch have slightly higher energy contents; an example is pitch pine. Such woods contain more resins, gums, oils and tannins than most. In practice, the very high energy content of resins together with the fairly large range of resin content in different woods probably makes this component the most important factor accounting for the differences in energy content in different woods. For instance, if 8600 Btu per pound is taken to be the energy content of wood excluding the resins, then wood which is 5 percent resins (which contain 17,400 Btu per pound) has an overall energy content of 9040³ per pound, an increase of 5 percent.

Softwoods tend to have more resin, and this is a reason for their generally slightly higher energy values. Native American trees can be divided into two groups

hardwoods, which have broad leaves, and softwoods which have leaves in the form of needles (e.g., pines) or flat needles (e.g., cedars). Softwoods are also called conifers since all native species have cones. Most softwoods are evergreen; the exceptions are tamarack, larch, and cypress. Most hardwoods are deciduous; they drop their leaves and grow new ones each year. Softwoods are not necessarily softer than hardwoods. For instance, the softwood, Douglas fir, is as hard as yellow poplar, a hardwood, and aspen, a hardwood, is in fact softer than white pine, a softwood. On the average, softwoods contain more resins than do hardwoods.

In summary, the similarities between woods are more striking than the differences with regard to their energy content when reported on a per-pound basis and at equal moisture content.⁴ 8600 Btu per pound at zero moisture content is a generally accepted value for all hardwoods and all but very resinous softwoods.

In fact, since good measurements on a large variety of firewoods is lacking, most lists of energy content per cord are computed from the assumption of uniform energy content per unit weight of wood (of the same moisture content), and use solely the difference in weight per cord to estimate the difference in energy per cord. In this approximation, a table of relative densities (Table 3-1) is essentially equivalent to a table of relative energy contents per cord — the denser the wood, the more energy a given volume of it contains.

TABLE 3-1.

SPECIES	RELATIVE DENSITY OR SPECIFIC GRAVITY	MOISTURE CONTENT OF GREEN WOOD (PERCENT)	
		Heartwood	Sapwood
Hardwoods			
Alder, red	.41	—	97
Apple		81	74
Ash:			
Black	.49	95	—
Blue	.58	—	58
Green	.56		
Oregon	.55		
White	.60	46	44
Aspen:		95	113
Bigtooth	.39		
Quaking	.38		
Basswood, American	.37	81	133
Beech, American	.64	55	72
Birch:			
Paper	.55	89	72
Sweet	.65	75	70
Yellow	.62	74	72
Butternut	.38		
Cherry, black	.50	58	—
Chestnut, American	.43	120	—
Cottonwood:			
Balsam poplar	.34		
Black	.35	162	146
Eastern	.40		
Elm:			
American	.50	95	92
Cedar		66	61

SPECIES	RELATIVE DENSITY OR SPECIFIC GRAVITY	MOISTURE CONTENT OF GREEN WOOD (PERCENT)	
		Heartwood	Sapwood
Rock	.63	44	57
Slippety	.53		
Hackberry	.53	61	65
Hickory, pecan:			
Bitternut	.66	80	54
Nutmeg	.60		
Pecan	.66		
Water	.62	97	62
Hickory, true:			
Mockernut	.72	70	52
Pignut	.75	71	49
Red		69	52
Sand		68	50
Shagbark	.72		
Shellbark	.69		
Honeylocust	.66*		
Locust, black	.69		
Magnolia:		80	104
Cucumbertree	.48		
Southern	.50		
Maple:			
Bigleaf	.48		
Black	.57		
Red	.54		
Silver	.47	58	97
Sugar	.63	65	72
Oak, California black		76	75
Oak, red:			
Black	.61		
Cherrybark	.68		
Laurel	.63		
Northern red	.63	80	69
Pin	.63		
Scarlet	.67		
Southern red	.59	83	75
Water	.63	81	81
Willow	.69	82	74
Oak, white:			
Bur	.64		
Chestnut	.66		
Live	.88		
Overcup	.63		
Post	.67		
Swamp chestnut	.67		
Swampy white	.72		
White	.68	64	78
Sassafras	.46		
Sweetgum	.52	79	137
Sycamore, American	.49	114	130
Tanoak	.64*		
Tupelo:			
Black	.50	87	115
Swamp		101	108
Water	.50	150	116
Walnut, black	.55	90	73
Willow, black	.39		
Yellow-poplar	.42	83	106
Softwoods			
Baldcypress	.46	121	171
Cedar:			
Alaska-	.44	32	166
Atlantic white-	.32		
Eastern redcedar	.47	33	---
Incense-	.37	40	213
Northern white-	.31		

	RELATIVE DENSITY		
Port Orford	.43	50	98
Western red cedar	.32	58	249
Douglas fir:			
Coast	.48	37	115
Interior West	.50		
Interior North	.48		
Interior South	.46		
Fir:			
Balsam	.36		
California red	.38		
Grand	.37	91	136
Noble	.39	34	115
Pacific silver	.43	55	164
Subalpine	.32		
White	.39	98	160
Hemlock:			
Eastern	.40	97	119
Mountain	.45		
Western	.45	85	170
Larch, western	.52	54	110
Pine:			
Eastern white	.35		
Jack	.43		
Loblolly	.51	33	110
Lodgepole	.41	41	120
Longleaf	.59	31	106
Pitch	.52		
Pond	.56		
Ponderosa	.40	40	148
Red	.46	32	134
Sand	.48		
Shortleaf	.51	32	122
Slash	.59		
Spruce	.44		
Sugar	.36	98	219
Virginia	.48		
Western white	.38	62	148
Redwood:			
Old-growth	.40	86	210
Young-growth	.35		
Spruce:			
Black	.40	34	128
Engelman	.35	51	173
Red	.41	34	128
Sitka	.40	41	142
White	.40	34	128
Tamarack	.53	49	---

*Estimates.

TABLE 3-1. Density and moisture content of some American woods. The energy per cord of wood species is approximately proportional to the density; the box at the bottom of the table gives the conversions from density to the more common units of millions of Btu per cord. Densities are given relative to the density of water, or equivalently, in grams per cubic centimeter; to convert to pounds per cubic foot, multiply by 62.3. The densities are averages; 10 percent variations among different samples of the same species are common. The densities are based on oven-dry weight and volume at 12 percent moisture content. Moisture contents are based on oven-dry weight. Different common names are often used for the same species. The scientific names corresponding to the common names used in this table are in the source below for most species, as well as some alternative common names. Most fruit trees are not included in the above list. Most fruit wood is relatively dense, and is considered to be excellent fuel.

(Data from Forest Products Laboratory, *Wood Handbook*, Tables 3-3 and 4-2, Agricultural Handbook No. 72, U.S. Department of Agriculture, 1974.)

TABLE 3-1 CONTINUED

RELATIVE DENSITY	HIGH HEAT VALUE PER CORD ¹ (Million Btu)
.30	12.6
.35	15.0
.40	17.1
.45	19.3
.50	21.4
.55	23.6
.60	25.7
.65	27.9
.70	30.0
.75	32.1
.80	34.3
.85	36.4
.90	38.6

¹Assuming 80 cubic feet of solid wood per cord, and 8600 Btu per pound of oven-dry wood. For very resinous woods, high heat values are a few percent higher. High heat values per cord do not depend on the wood's moisture content except through the shrinkage of wood as it dries.

Some confusion can arise when comparing lists of energies per cord of various woods because the actual amount of solid wood in a cord depends on the straightness and length of the pieces, and how it is piled. Some authors assume 80, others 90, cubic feet of solid wood in a cord (a cord has an overall volume of 128 cubic feet including the spaces between the pieces of wood). The difference between the assumptions of 80 and 90 cubic feet per cord result in a difference of about 12 percent between reported energies per cord. Actual cords may actually contain from 60 to 100 cubic feet of solid wood. Thus, in practice, there is a very large variability in the amount of energy per cord even for a given kind of wood.

The larger (20-40 percent) discrepancies between some lists of woods are due to the different ways of reporting energy contents. All the wood energies given up to this point have been the total chemical energy in wood, as measured in a bomb calorimeter, where the final temperature of the combustion products is essentially room temperature, and where virtually all water vapor generated condenses into liquid water. The heat value measured this way is the high (or gross) heat value. It represents the most heat that could possibly be derived from the burning of wood.

But when wood is burned in a stove or fireplace, the water vapor in the flue gases rarely condenses, especially where the released heat can be used. In fact, such condensation anywhere in the heating system is to be avoided for reasons of safety (related to creosote — see Chapter 12), and chimney life expectancy (due to corrosion). Since the latent heat part of the energy is essentially unavailable for heating, its contribution is frequently subtracted out from the high heat value, yielding the low heat value.

The difference is significant. As mentioned previously, there are two sources of water vapor in the exhaust of a fire, and low heat values take both into account. Wood contains water (its moisture content), and water vapor is also manufactured in the combustion process. When burned completely, each pound of oven-dry wood produces about 0.54 pound of water vapor.⁵ For wood with a moisture content of 25 percent there is another quarter pound of water vapor

going up the chimney for each piece burned whose oven-dry weight would be 1 pound. The total amount of water vapor is 0.79 pound, which represents about 830 Btu of potential energy.⁶ The assumption behind the concept of low heat value is that this energy is not usable. The low heat value of wood with a 20 percent moisture content is thus about 830 Btu less than its high heat value, or about 7770 Btu per piece whose oven-dry weight would be 1 pound, a decrease of about 9 percent.⁷ The effect at other moisture contents is illustrated in Figure 3-4.

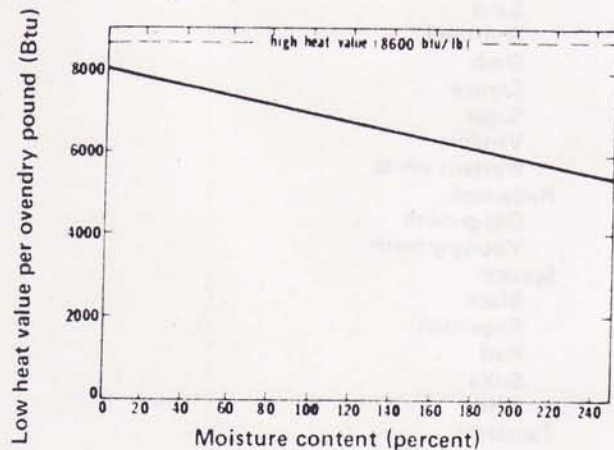


Figure 3-4. Low heat value per piece of wood as a function of moisture content, assuming the piece would weigh one pound if it were oven-dry. This represents the maximum amount of useful heat which combustion could yield if no water vapor condenses.

The water vapor in the flue gas, along with everything else, also carries away sensible heat. As long as the gases leave the house at any temperature above room temperature, some of the heat generated in the fire was not recovered as useful heat in the house. Some authors have incorporated an estimate of this loss in their lists of available energy of different woods by making quite arbitrary assumptions about flue gas temperatures and the amount of combustion air. This is not appropriate. The amount of heat lost up the

chimney is not a property of the wood burned, but of the heat transfer properties of the stove and chimney, and thus belongs rather in a discussion of the energy efficiencies of stoves (Chapter 6), not in a list of wood types.

When assessing the energy content of a cord of fire wood, the most important parameter is the oven-dry density of that kind of wood, since a pound of dry wood of any kind has nearly the same energy. The densest woods have the most energy per cord (at equal moisture content). Table 3-1 gives the densities of many types of wood. Moisture in wood decreases its useful energy. If all types of wood had the same cost per cord, the better buy would be the denser woods in Table 3-1. If wood were sold by the ton, as is sometimes the case, the best buy in terms of energy would be the driest wood. No fuelwood dealer I am aware of sells wood by its energy content (e.g., \$50 for 20 million Btu). Reasonably accurate Btu assessments would require both weighing and a determination of moisture content.

BURNING QUALITIES

Softwoods are often said to burn faster and hotter than hardwoods and are usually preferred for kindling. Hardwoods are generally felt to last longer in a fire and generate more coals.

Careful experimental measurements support most of these notions, but with the wood's density as the critical variable, not its classification as a softwood or a hardwood.

Figure 3-5 shows that the denser a wood is, the longer it takes for a given size piece to be consumed — the volume consumption rate is highest for light woods like balsa. Denser woods last longer in a fire. But the rate of decrease of weight as the wood burns is very nearly the same for all woods (Figure 3-6). Since all woods have nearly the same energy for the same weight of wood, equal weight loss rates imply equal energy release rates. This means that the heat output of a stove, under steady burning conditions, does not depend critically on the kind of wood used. (Temperatures were also measured during some of the experiments, and the maximum temperatures achieved were all about the same.) But the low density woods do ignite more quickly — they can sustain their own flames

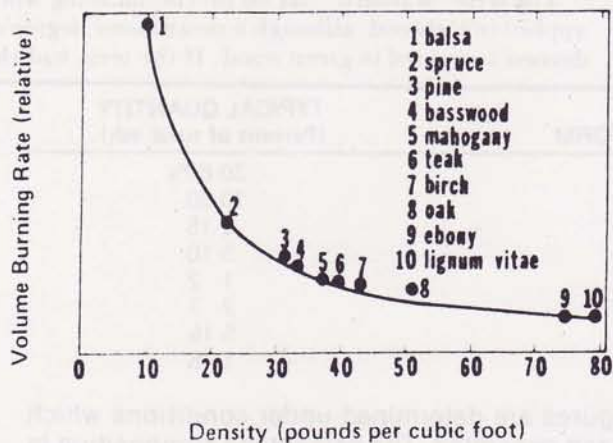


Figure 3-5. Volume burning rate, as a function of density. From L. Metz.⁸

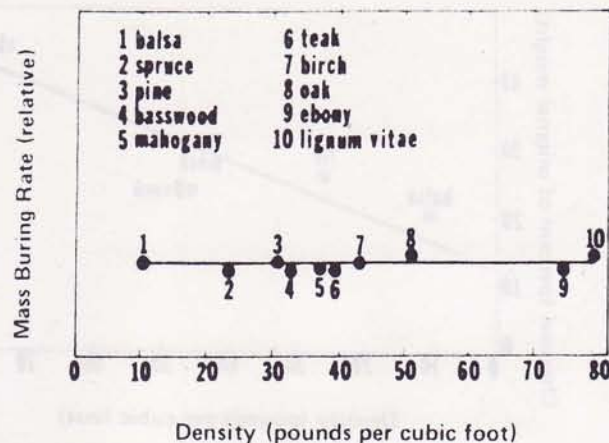


Figure 3-6. Mass burning rate, as a function of density. From L. Metz.⁸

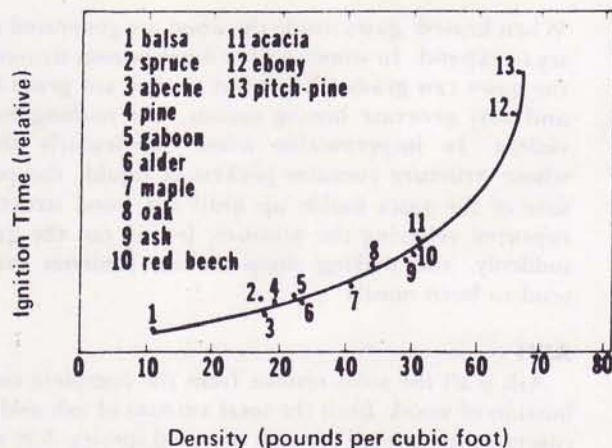


Figure 3-7. Ignition time as a function of wood density. From L. Metz.⁸

sooner (Figure 3-7). This makes light woods preferable as kindling, and it means that a stove will heat up more quickly with low density wood as the fuel. This quickness of ignition may be partly what gives the impression of a hotter fire. Figure 3-8 indicates that when the flames die out, the mass of wood (mostly charcoal) still remaining is highest for dense woods; dense woods produce relatively more coals. In the case of light woods, more of the charcoal is burned while the gases are still burning.⁸

Density is the single most important property of wood that differentiates its burning characteristic. Woods containing relatively large amounts of pitch have slightly higher energy content and probably burn with larger flames. Use of pitchy woods also often results in more creosote. Some woods (such as oak) have relatively concentrated regions in their structure containing pores or open channels which may affect the way they burn (such woods are said to be ring-porous). The mineral content of woods (which is left as ash) may affect burning characteristics.

Some woods burn noisily. Common sounds are hissing and crackling, but some woods can even burn explosively. These sounds are characteristics of woods whose structures are relatively impermeable to gases.

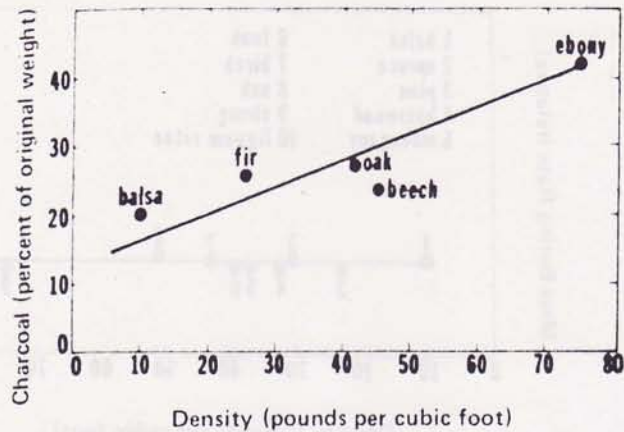


Figure 3-8. Percentage of original weight left as charcoal after large flames have died out. From L. Metz.⁸

When heated, gases inside the wood are generated and try to expand. In woods with a more porous structure, the gases can gradually get out as they are generated and may generate hissing sounds, but nothing more violent. In impermeable wood, particularly those whose structure contains pockets of liquid, the pressure of the gases builds up until the wood structure ruptures, relieving the pressure, letting out the gases suddenly, and making sharp sounds. Resinous woods tend to burn noisily.

ASH

Ash is all the solid residue from the complete combustion of wood. Both the total amount of ash and its composition depend not only on wood species, but also on the amount of bark included, on the ratio of heartwood to sapwood, and whether the wood came from the trunk or the branches of the tree.⁹ Ash content typically is between 0.1 and 3 percent.¹⁰ Ash content is rarely considered an important consideration in choosing firewood types.

The composition of ash is indicated in Table 3-2. Wood ash is useful as a fertilizer, particularly because of its potassium content. Potassium carbonate can be extracted from wood ash and used in making soap. Wet ash is caustic, as is lye, and can be used as a degreasing cleaner. Ashes will also decrease the acidity of garden soil.

GREEN WOOD

Green wood has disadvantages. It is always heavier (roughly twice as heavy) and thus a little harder to handle. Green wood is also more troublesome to ignite and keep burning, and contains less available energy. When it is burned in a stove, some of the wood's chemical energy must be used to evaporate or boil the moisture. For this and other reasons (page 30), less useful heat is derived from green wood.

Different kinds of green wood are actually quite different from each other in these respects. White ash is relatively easy to burn when green; most softwoods are very difficult. The principle reason is the difference in moisture content. Table 3-1 lists moisture contents of green woods. If one must burn green wood and there is a choice, species with the lower moisture content are the best choice. Heartwood is considerably drier than sapwood; in a desperate situation, heartwood could be separated from sapwood.

Burning moist wood can be advantageous. Because of its moisture content, green wood burns more slowly. Thus, when one is primarily interested in obtaining a steady low heat output over a long period of time, such as overnight, mixing some green wood in with seasoned wood can help. The appropriate proportion of green wood and its size distribution must be learned through experience; the amount depends critically on how moist the green wood is, and on the type of stove it is burned in; if too much is used, the fire will die out.

WOOD STORAGE

After being cut, green wood dries (or seasons), quickly at first and then at a slower and slower rate. Because wood is hygroscopic (it attracts water), it never dries to zero moisture content in any normal storage situation. Rather, its moisture content gradually approaches an equilibrium value which depends on the storage conditions. For covered wood, this final moisture content is given in Table 3-3; the relative humidity of the surrounding air is the main determining factor. In the Southwest in the summer, the moisture content of wood stored outdoors may be as low as 6 percent; in parts of the Northwest in winter, the moisture content of (covered) seasoned wood cannot be much less than 18 percent.

The term "seasoned" has no precise meaning when applied to fuelwood, although it means some degree of dryness compared to green wood. If the term had the

ELEMENT	ASSUMED FORM	TYPICAL QUANTITY (Percent of total ash)
Calcium	CaO	30-60%
Potassium	K ₂ O	10-30
Sodium	Na ₂ O	2-15
Magnesium	MgO	5-10
Iron	F ₂ O ₃	1-2
Silicon	SiO ₂	2-7
Phosphorous	P ₂ O ₅	5-15
Sulphur	SO ₃	1-5

TABLE 3-2. Composition of wood ash. These figures are determined under conditions which ensure complete combustion, and retention of all ash generated. The percentage composition is calculated assuming the elements are in the stated chemical form; the actual chemical forms may be different. [Data interpreted from L.E. Wise, Editor, *Wood Chemistry*, (New York, Reinhold Publ. Corp., 1944). p. 435]

same meaning as it does when applied to paper, seasoned wood would be wood whose "moisture content is uniform and in equilibrium with that of the surrounding air,"¹¹ i.e., wood which is as dry as it can get, given its surroundings (Table 3-3).

The *time* it takes for wood to season depends principally on the size of the pieces, on how freely air can circulate around the piece's surfaces, and on the temperature. The smaller the pieces, the faster they will dry; thus splitting accelerates drying. Air circulation is better in free standing wood piles than in piles next to buildings. Also, if rows are placed immediately next to each other, air will circulate less freely than if they are spaced apart a few feet. Piling wood with alternating orientations (criss-crossed) also lets more air through. Direct exposure to sunlight helps speed drying by its warming effect, as does indoor storage in a heated room.

Actual drying times will vary significantly depending on the above considerations. Firewood will generally be very close to its equilibrium moisture content (as dry as it can get) after two years of seasoning. Drying is fastest at the beginning; after six months of drying, wood is often called "seasoned," and usually has an acceptably low moisture content of 25 percent or less.

Covering wood can decrease both the final moisture content, and the drying time, particularly in climates with relatively heavy precipitation. A shed without tight walls, or without walls at all, is excellent, since it protects against precipitation but does not inhibit air flow. However, in very dry climates, a shed may not help because its shading of the wood may offset its protection against the small amounts of precipitation. A plastic sheet which completely covers a wood pile down to the ground is usually worse than no cover since it inhibits circulation and tends to hold moisture in, including moisture coming out of the ground (which can be considerable). One simple way to achieve some protection against precipitation is with a cover made of 2 to 3 foot wide strips of plastic, fastened along their long edges to poles or small boards. The weight of the poles hanging over the sides keeps the plastic strip in place on top of the pile. Ideally, wood piles should be kept a foot or more above the

ground (e.g., on concrete blocks). Not only is the ground itself often damp in most climates, but the humidity of the air close to the ground is also usually higher than the humidity in the rest of the air.

Storing wood in a heated space, such as a heated basement or garage, will speed up the drying process. The equilibrium moisture content will also be lowered, particularly if the air is not humidified. Wood stored indoors in a heated space in New England will have a moisture content of less than 10 percent after about two years. The reason is that the air is very dry in a heated but unhumidified structure in cold weather. However, indoor storage is not always advisable. Insects which are detrimental to wood buildings, such as termites, may be living in the fuelwood and may spread to the house. State university extension services or the U. S. Department of Agriculture should be able to give advice on the advisability of indoor storage for particular regions of the country.

If stored for too long a time, wood is capable of becoming useless as fuel due to its rotting. Rotting is caused by the growth of fungi; the fungi convert the wood into water, carbon dioxide, and heat, just as does a fire. Thus rotting decreases wood's energy. The fungi are most productive when three conditions are met: the temperature is between 60 and 90 degrees Fahrenheit, the wood's moisture content is above about 30 percent, and ample oxygen is available.

Virtually no rotting takes place in cold winters because the temperature is too low for the fungi. Wood in the interior of a house does not rot because it is too dry. Wood kept continuously underwater seldom rots, partly because of a lack of oxygen, and partly due to the usually cool temperature. On the other hand, wood which is lying on the ground, especially in summer usually provides a productive environment for fungi because the ground keeps the wood sufficiently moist. Rot will appear first at the bottom of a wood pile placed directly on the ground. The most practical way to retard rotting of fuelwood is to help it dry quickly and to keep it dry, especially during the warm summer months during which most decay occurs.

Woods differ in their natural resistance to decay. The sapwood of virtually all species is highly susceptible to decay, but there is a considerable difference

RELATIVE HUMIDITY (percent)	EQUILIBRIUM MOISTURE CONTENT (percent)
5	1.2-1.4
10	2.3-2.6
20	4.3-4.6
30	5.9-6.3
40	7.4-7.9
50	8.9-9.5
60	10.5-11.3
70	12.6-13.5
80	15.4-16.5
90	19.8-20.0
98	26.0-26.9

TABLE 3-3. Equilibrium moisture content of wood as a function of the surrounding air's relative humidity.¹² The actual moisture content of very thin pieces of wood varies daily and even hourly as the air's relative humidity changes. The moisture content of wood logs varies much more slowly, following monthly and seasonal changes in average relative humidity. [Data from Forest Products Laboratory, *Wood Handbook*, Agricultural Handbook No. 72, p. 3-8, U.S. Department of Agriculture (1974).]

among heartwoods, as indicated in the Table 3-4. Given the choice, the more susceptible species should be burned first so that less of their energy content will be dissipated by the fungi. The most susceptible woods can decay significantly in two years of outdoor, un-covered, exposure in climates with warm, humid summers.

SUMMARY

The two most important aspects of fuelwood are its dryness and its density. Wood containing too much moisture is often very difficult to ignite and keep burning. In addition, stoves and fireplaces have lower energy efficiencies when burning moist wood.

On the basis of oven-dry weight, all woods have ap-

proximately the same energy content. Thus a pound of (oven-dry) oak and a pound of (oven-dry) pine will yield about the same amount of heat when burned. But a cord of oak contains considerably more energy than a cord of pine, because it weighs more—oak is a denser wood. Thus, if the price per cord is the same, the best buy is the denser or heavier wood type.

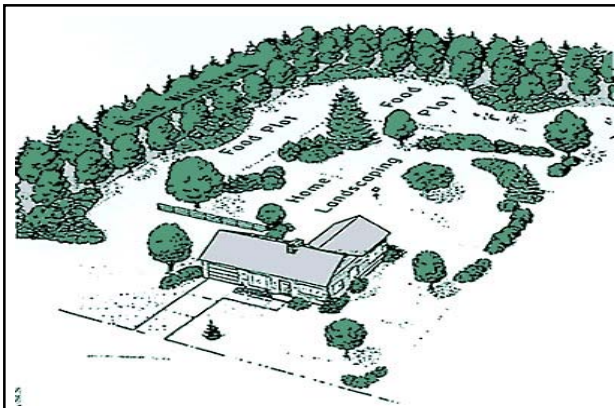
All wood types are satisfactory as fuel. Some types burn more quickly, requiring more frequent refueling, some generate longer-lasting coals, some burn more noisily, some require less time to season, and some ignite more easily and are thus especially suitable as kindling. But no common wood type is truly unsuitable as fuelwood. In practice, people burn whatever is most readily available.

MOST RESISTANT	HIGHLY RESISTANT	MODERATELY RESISTANT	LEAST RESISTANT
Locust, black	Baldcypress	Douglas-fir	Alder
Mulberry, red	Catalpa	Honeylocust	Ashes
Osage, orange	Cedars	Larch, western	Aspens
Yew, Pacific	Cherry, black	Oak, swamp chestnut	Basswood
	Chestnut	Pine, eastern white	Beech
	Cypress, Arizona	Southern Pine:	Birches
	Junipers	Longleaf	Buckeye
	Mesquite	Slash	Butternut
	Oak:		Cottonwood
	Bur	Tamarack	Elms
	Chestnut		Hackberry
	Gambel		Hemlocks
	Oregon white		Hickories
	Post		Magnolia
	White		Maples
	Redwood		Oak (red and black species)
	Sassafras		Pines (other than long leaf, slash, and eastern white)
	Walnut, Black		Poplars
			Spruces
			Sweetgum
			True firs (western and eastern)
			Willows
			Yellow-popular

TABLE 3-4. Relative resistance of the heartwood of various species to decay. The sapwood of all species has little resistance to decay. [From U.S. Forest Products Laboratory, *Wood Handbook*, Agriculture Handbook No. 72, p. 3-17, U.S. Department of Agriculture (1974).]

Abstract: Integrating trees and shrubs with the other enterprises on a farm can create additional sources of income, spread farm labor throughout the year, and increase the productivity of the other enterprises, while protecting soil, water, and wildlife. Agroforestry systems include alleycropping, silvopasture, windbreaks, riparian buffer strips, and forest farming for non-timber forest products. While they clearly offer economic and ecological advantages, these systems also involve complex interactions, which complicate their management. When designing an agroforestry enterprise, one should research the marketing possibilities and include the agroforestry system in the complete business plan for the farm. This publication presents the principles of agroforestry, an overview of common practices, marketing considerations, several case studies, and an extensive list of further resources.

By **Alice Beetz**
NCAT Agriculture Specialist
June 2002



Trees add beauty and serve as a windbreak.

INTRODUCTION

Agroforestry is a farming system that integrates crops and/or livestock with trees and shrubs. The resulting biological interactions provide multiple benefits, including diversified income sources, increased biological production, better water quality, and improved habitat for both humans and wildlife. Farmers adopt agroforestry practices for two reasons. They want to increase their economic stability and they want to improve the management of natural resources under their care.

A traditional tree farm or nut plantation managed as a single-purpose monocrop is not an agroforestry system. Neither is a woodlot when it's managed for wood products only. Agroforestry involves combining a tree planting with another enterprise—such as grazing animals or producing mushrooms—or managing a woodlot for a diversity of special forest products. For example, an agroforestry system might produce firewood, biomass feedstocks, pine-straw mulch, fodder for grazing animals, and other traditional forestry products. At the same time, the trees are sheltering livestock from wind or sun, providing wildlife habitat, controlling soil erosion, and—in the case of most leguminous species—fixing nitrogen to improve soil fertility.

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Agroforestry practices in use in the United States include alleycropping, silvopasture, windbreaks and shelterbelts, riparian buffer strips, and forest farming (special forest products). An overview of each of these major systems is presented below.

AGROFORESTRY PRACTICES

1. Alleycropping

Alleycropping involves growing crops (grains, forages, vegetables, etc.) between trees planted in rows. The spacing between the rows is designed to accommodate the mature size of the trees while leaving room for the planned alley crops. When sun-loving plants like corn or some herbs will be alleycropped, the alleyways need to be wide enough to let in plenty of light even



While trees mature, crops provide income.

when the trees have matured. Alternatively, the cropping sequence can be planned to change as the trees' growth decreases the available light. For example, soybeans or corn could be grown when the trees are very small; then, as the tree canopy closes, forages could be harvested for hay; finally, when the trees are fully grown and the ground is more shaded, grazing livestock or shade-tolerant crops like mushrooms or ornamental ferns could occupy the alleyways.

Like all integrated systems, alleycropping requires skillful management and careful planning. Both the crop and the trees have requirements

that sometimes necessitate trade-offs between them. The design must allow sufficient room for the equipment needed to service each enterprise. If either crop requires chemical herbicides or insecticides, the other must be tolerant of these treatments. In the case of livestock, there may be periods during and after chemical use when animals must be withdrawn from the area. Livestock can cause damage, even when the trees are fully grown; roots injured by livestock hooves are susceptible to disease. Soil compaction is a danger in wet weather. These examples indicate how crucial planning is to the ultimate success of an agroforestry system.

In most alleycropping systems, trees are planted in straight rows, sometimes with no regard for

Bob Carruthers, a crop farmer in Morrilton, Arkansas, faced the choices of getting bigger, getting out of commodity crop farming, or waiting to be pushed out. He decided to plant pecans on his laser-leveled fields and to continue cropping in the alleys while the trees grow. He chose several pecan varieties that are in demand on the market and have an extended ripening season. He planted them 35 feet apart with 60-foot alleyways, installed micro-sprinklers for irrigation, and fertilized, based on soil and leaf-tissue tests, for several years. Four years after establishment, he is already harvesting a few pecans and selling them retail for \$1.50 per pound. He plans to buy a mechanical sheller so that he can add more value to his product and continue to sell direct without depending on a wholesaler.

In the 60-foot alleys, Carruthers plants no-till wheat and soybeans, with a 17% reduction in yield as compared to his former monocropped fields. He has planned for the change in light availability as the trees mature; when sunlight limits soybean production, he will grow only wheat in the alleys. At year 22 or thereabouts, he will take out every other tree in the row, leaving a 60-foot by 70-foot spacing. Having originally estimated that he would regain the establishment costs in 13 years, he now expects to do so in 10 or 11 years. Meanwhile, the cropping system contributes cash flow in these early years when tree revenue is minimal.

slope or contour. There are, however, advantages to planting the trees in curves or on the contour. These include the slowing of surface-water movement and the reduction of soil erosion. The trees can be planted in single rows or in blocks of multiple rows between alleys. The first row in a block is planted on the contour line; subsequent rows are planted below the original line according to the slope of the land. The final row of trees in one block is planted parallel to the contour line on which the next block of trees will begin. The width of the tree blocks varies, but the cropping alleyways between them have parallel edges. This design avoids creating point rows within the alleys, thus simplifying crop equipment maneuvers. The width of the alleys is determined by the size of this equipment.

If planting on the contour is impractical, another option is to plant trees in curved zigzags so that water running downhill is captured or at least slowed. Islands of trees can offer some of the same advantages if they don't interfere with cropping operations.

In large plantings, fast-growing hardwoods or pines are interplanted as trainers to ensure that the crop trees develop upright, unbranched trunks. Alternatively, the crop trees can be planted close together in the rows, to be thinned and pruned several times as they grow. Although these early-harvested trees may have little market value, their presence during the first years of growth has increased the main crop's value. The goal is to produce long, straight sawlogs with few lower branches, for maximum profit at final harvest. Whatever the planting design, trees on the outside edge of a group will grow more side branches, or even a lopsided trunk, resulting in lower-value sawlogs.

2. Silvopasture

Tree and pasture combinations are called *silvopastoral agroforestry*. Hardwoods (sometimes nut trees) and/or pines are planted in single or multiple rows, and livestock graze between them. Although both the trees and the livestock must be managed for production, some systems emphasize one over the other. Usually, in the early years of establishment, crops or hay are harvested

Tom Frantzen and his family are innovative farmers in northeastern Iowa. In 1992, they began an intercropping experiment by planting double rows of hybrid cottonwood trees at even spacings across one of their fields, with alternating strips of corn and oats in the alleys. The oats are underseeded with red clover, and every third alley strip is a second-year stand of red clover. From a distance the field has an attractive striped pattern. Each year the oats are combined and the straw is baled. The red clover underseeded in the oats is lightly grazed as a new seeding, and then used as pasture in the second year.

Every year, a farrowing hut is placed on each second-year clover strip. Bred gilts graze on clover (or alfalfa) while the adjacent crops and trees are protected from damage with two strands of portable electric wire. Six pounds of ground corn and minerals per gilt supplement the pasture to ensure proper nutrition prior to farrowing. In the fall, the growing pigs and lactating sows harvest the corn strips. Grazing both the corn and the red clover keeps harvest costs to a minimum. The corn and trees separate the groups of sows and pigs, provide a windbreak, and offer shade in the heat (1).

from the planting. Grazing generally begins after two or three years, when the trees are large enough that the livestock can't damage them. In other instances, tree tubes and electric fencing protect the young trees, and grazing begins immediately.

Grazing livestock on silvopasture eliminates some of the costs of tree maintenance. With good grazing management, for example, herbicides and mowing may become unnecessary. Grazing also enhances nutrient cycling and reduces commercial fertilizer costs; the animals remove few nutrients, and their waste is a valuable input for the trees. Well-managed grazing will increase organic matter and improve soil conditions. However, controlling the number of animals per acre, limiting the number of days those animals remain on each site, and avoiding compaction are critical for a successful silvopasture system.

Competition for water between the pasture and the trees may be a concern. In a silvopasture with nut trees, for example, seasonal water shortages during late summer can negatively affect nutfill and the production of fruit buds for next year's harvest. Irrigation is justified in such a situation if the trees are being managed for nut production. Water competition may not be as critical for *timber* silvopastures.

Further information about silvopastoral systems is available from the National Agroforestry Center and other resources listed at the end of this publication.



Grazing sheep replace the mower in Christmas trees.

3. Windbreaks or Shelterbelts

Extensive research on windbreaks, also called *shelterbelts*, has been carried out in the U.S. Trees are planted in single or multiple rows along the edge of a field to reduce wind effects on crops or livestock. Windbreaks have been shown to reduce wind impact over a horizontal distance equalling at least ten times the height of the trees. Wind and water erosion are reduced, creating a moist, more favorable microclimate for the crop. In the winter the windbreak traps snow, and any winter crops or livestock are protected from chilling winds. Beneficial insects find permanent habitat in windbreaks, enhancing crop protection.



A windbreak protects Iowa crops.

Although the trees compete for available water along the edges between the windbreak and the crop rows, potentially reducing crop yield near the windbreak, the net effect on productivity is positive. In fact, even on land that's well suited for high-value crops, a windbreak can increase the crop yield of the entire downwind field by as much as 20%, even when the windbreak area is included in the acreage total (2).

Windbreaks can be designed specifically for sheltering livestock. Studies have shown the economic advantages of providing protection from windchill, a major stress on animals that live outside in the winter. Reduced feed bills, increases in milk production, and improved calving success have resulted from the use of windbreaks. The National Agroforestry Center (see **Further Resources**) offers a series of booklets on windbreak technology as well as a publication entitled *Outdoor Living Barns*. Another resource, focused specifically on incorporating trees into family farms, is *Shelter and Shade* by John and Bunny Mortimer (3).

Besides providing protection to crops and livestock, windbreaks offer other advantages. They

benefit wildlife, especially by serving as continuous corridors along which animals can safely move. Farmers can even develop windbreaks into additional profit centers for the farm – hunting leases, selective timber harvests, firewood sales, and special forest products are some of the possibilities (these marketing options are discussed below).

Any tree species can be used in a windbreak. However, deciduous species, even in multiple rows, will lose effectiveness when they lose their leaves. For year-round use, some of the species selected should be evergreen. Fast-growing trees should be included; it's best to plant deep-rooted, non-competitive species along the edges. Regular deep chisel-plowing along the edges will keep roots from spreading into the crop rows. If some of the trees are harvested periodically, replacements can be planted, establishing a long-term rotation within the windbreak.

Farmers in the upper Midwest are investing in hybrid hazelnut or poplar plantings as part of their crop and livestock systems. They are integrating them into the farm to provide benefits such as windbreaks, terraces, or riparian buffers. Using livestock wastes as a part of the fertility program is being investigated.

The newly introduced hybrid hazelnut takes the form of a bush (most hazelnuts have been raised as small trees in the northwestern U.S.). These plants are resistant or tolerant to eastern filbert blight, which is a serious threat to the industry in the Northwest. The demand for the nut is large and established. Midwestern farmers are exploring cooperative marketing options. Harvesting equipment appropriate for these plantings is being developed.

4. Riparian Buffer Strips

Trees, grasses, and/or shrubs planted in areas along streams or rivers are called *riparian buffers* or *filter strips*. These plantings are designed to catch soil, excess nutrients, and chemical pesticides moving over the land's surface before they enter waterways. Such plantings also physically



Buffers protect water quality.

stabilize streambanks. On cropland that is tilled to improve drainage, polluted water can flow directly into streams; constructed wetlands installed in the buffers can capture and clean this drainage water before it enters the stream.

Forested areas along streams fulfill other needs of the community at large by storing water and by helping to prevent streambank erosion, which in turn decreases sedimentation downstream. These areas protect and enhance the aquatic environment as well. Shading the water keeps it cooler, an essential condition for many desirable aquatic species. Buffer strips also provide wildlife habitat and can be managed for special forest products.

Crop and livestock farmers, as well as local communities, have become aware of the threat that agricultural practices can pose to pure drinking water. Consequently, there are federal, state, and local government programs to assist in the design and planting of riparian buffer strips. The federal Continuous Conservation Reserve Program can be used for this purpose. The local Farm Services Administration office can advise on this program and other options. Conservation organizations are another potential resource. Some offer conserva-

tion easements or trusts when land is permanently withdrawn from agricultural production.

5. Forest Farming and Special Forest Products

When a natural forested area is managed for both wood products and an additional enterprise, it becomes an agroforestry system. For help with the management of timber, county Extension agents can refer farmers to Extension forestry specialists. These specialists are qualified to give advice on thinning, pruning, and harvesting practices, as well as on marketing options. They may or may not be able to visit the farm for on-site consultation. The Association of Consulting Foresters of America (See **Further Resources** below) can refer you to private forestry consultants in your area.

Besides producing saw timber and pulpwood, woodlands can generate income from many other products. Established forests offer many non-timber "special forest products" that contribute to cash flow without requiring the one-time harvest of old trees. For example, landowners can manage established woods to encourage

The number of products that a woodland can contribute is limited only by the owners' imaginations and their ability to identify and exploit a profitable market. Here are a few examples:

- fruits, nuts, berries
- honey and other hive products
- mushrooms
- herbs and medicinal plants
- materials for basket-making or chair-caning
- pine straw, boughs, pinecones
- plant materials as dried or fresh ornamentals
- bamboo
- aromatics
- fenceposts, firewood, smokewood
- decorative or odd wood, e.g. burls
- dye materials
- tree and shrub seeds, seedlings, and cuttings
- charcoal



Ginseng thrives under mature forest.

naturally occurring patches of berries or bitter-sweet. Or they might plant understory crops adapted to the forest type and climate. Growing mushrooms on logs is another, more labor-intensive, possibility; a canopy of either hardwoods or pine will provide the shade needed to maintain moisture for fruiting. See the ATTRA publication [Mushroom Cultivation and Marketing](#) for more information.

Berries and vines for crafts or basketry are examples of products that can be harvested and marketed without any costs of establishment; on the production end, they may require only that the canopy be managed for optimal light conditions. Some other examples of non-timber forest products are listed in the box on this page. For more information on special forest products, request the new ATTRA publication [Woodlot Enterprises](#), and visit the Web sites listed below under **Further Resources**.

THE BUSINESS OF AGROFORESTRY

1. Establishment Costs and Interim Income

Effort spent at the beginning of an agroforestry project on properly preparing the site and following the recommended planting procedures will pay off well later on. Depending on the type of project, establishment costs can be considerable. For an alleycropping system—or even a windbreak—destruction of existing vegetation and deep chiseling or ripping of the soil are mini-

mal requirements. A season of growing a cover crop before planting the trees, and use of mulch or landscape cloth to reduce early competition for water and nutrients, will increase the chances of quick, healthy growth. Lending institutions will likely require a good business plan in order to fund such a project, especially for a beginner. However, government support programs such as the continuous CRP (Conservation Reserve Program) or other program payments will help to defray these costs in some areas of the country. Consult with your local Farm Services Agency about whether such programs would apply to your acreage.



Raspberries between young pecan trees.

The delay until the income from a new planting begins to pay back these initial costs is a key consideration for most landowners. Alley crops and silvopastures provide income from the area between tree rows in this early stage. In addition, as a stand of same-age trees matures, some trees will be harvested in order to reduce competition as the trees begin to require more space. Although the early thinnings are not likely to be worth very much, the later ones may have some market value. It pays to investigate all the options, including marketing value-added products directly. Hardwood chips could be sold to a landscaping firm, for instance, or firewood may have nearby customers. Consider some of the “special forest products” mentioned above.

Nut trees produce income from the nuts long before the timber can be harvested. In fact, over the life of the planting, the value of the nut harvest of improved varieties is liable to surpass the value of the wood at final harvest. Black walnut is a valuable timber and nut tree, but it requires a good site and takes a long time (often eighty years) before timber harvest can begin. Early training and pruning, as well as managing fer-

Short-rotation Woody Crops

Several of the agroforestry practices described here can incorporate fast-growing trees such as poplar and willow. Called short-rotation woody crops, they are used in riparian buffers, windbreaks, or alleycrops. Harvested for biomass, fiber, or other products, such trees can produce a marketable crop in as few as ten years when managed intensively. Rapid initial growth requires a prepared site, adequate fertility and water, and competition controls (e.g., mulch, herbicide, weed barriers).

In some systems, after a tree is cut, one of the sprouts that grows from the stump is chosen as the replacement stem. After it has grown for several years, it is harvested and the process is repeated. This practice of repeatedly cutting and re-sprouting trees from an established root system is called coppicing. Alternatively, trees are simply harvested once, and new trees planted as replacements. Since new hybrids are continually being developed for use as short-rotation woody crops, producers might choose to completely re-plant in order to take advantage of newer genetic lines.

Short-rotation woody crops are of increasing interest to the energy and fiber industries. For example, in Minnesota, as native aspen forests are exhausted, the pulp industry has turned to hybrid poplars. They are being monocropped in plantations or included in farm agroforestry systems. In this case, the demand is established and so is the infrastructure to harvest and process the crop. These fast-growing trees are often planted in rotation for regular income. However, an all-in, all-out system can also be successful.

tility and pests, will maximize the value of both crops. Pecans, either native or improved varieties, have some of the same advantages and disadvantages. However, pecan trees are seldom harvested for timber while they are still producing because of the high value of the nut.

In the case of pines, boughs for the ornamental market and pine needles for landscaping mulch provide early income potential. Again, the total value of these products over the life of the stand can be more than that of the timber. The advantage of providing income while trees grow to maturity, however, can be critical to the cash-flow situation of the farm. In every system, the amount and type of management and labor required for interim and final products must be carefully weighed during the design stage.

Larry Godsey at the University of Missouri's Center for Agroforestry wrote an excellent publication on developing a budget that combines multiple enterprise budgets over the life of an agroforestry planting. *Economic Budgeting for Agroforestry Practices* is available from The Missouri Agroforestry Center (See **Further Resources** below). An on-line version can be downloaded from the Center's website.

2. Marketing

Thorough research into the markets available for each type of tree product is absolutely essential before committing to any forestry enterprise. For most forestry products, the buyer must be relatively close to the site. Otherwise, the transportation costs will eat up potential profits. Although short-rotation woody crops are a relatively new type of forestry without established markets, it is likely that regional markets will develop over time where there are customers such as ethanol producers, electric power producers, and the fiber industry.

Regions where forestry is a longstanding tradition are likely to have markets for all types of wood products (e.g., saw timber, chip and saw, pulpwood). Without such a forestry infrastructure already in place, it is risky to commit to an agroforestry system. However, because private lands are becoming a more important source of

tree products, new markets will develop in other regions. It is, of course, difficult to predict where, especially when planning for harvests twenty years or more in the future.

Careful consideration must be given not only to the marketing plan, but to the harvest plan as well. The planting design must accommodate harvest equipment and leave room for maintenance operations. Young trees are easily wounded, and these wounds provide entrance to pest organisms.

Thinning and pruning may generate sales if wisely marketed. This part of the planning process requires the advice of a forestry professional, whether a government agent or a private consultant. Remember that loggers and timber buyers are likely to have their own best interests in mind.

Landowners who want to add value to their forest products have some choices. One way is to certify that the forest and its harvest have been managed according to specified ecological standards. There are currently several "eco-label" certification programs. Eco-labeling has caught on in Europe where consumer recognition is high, but has not consistently earned premium prices in the U.S. Contact ATTRA for more information about forest certification programs.

In some cases, landowners can add value themselves, for example by cutting and selling firewood. Access to a portable sawmill can enable landowners to saw their own logs into lumber, air dry it, and sell it directly to specialty woodworkers. Other options, like selling pine thinnings as Christmas decorations, require imagination and marketing know-how. Fee hunting or wildlife photography, possibly combined with camping or bed-and-breakfast facilities, might also be considered.

3. Evaluating Agroforestry Options

Agroforestry systems are much more complex than single-purpose farm or forestry enterprises. Each component of the system — the trees as well as the crops or livestock — must undergo a series of evaluation procedures: testing against the

farm or family goals, evaluating resources, investigating promising options from a longer list of possibilities, making the choice, planning, and then implementing the plan and monitoring progress.

Evaluation of an agroforestry system requires collecting the following information (4):

- *Farm Accounts* – Income and expenditures for existing enterprises and potential ones, including fixed and variable costs.
- *Planting and Felling Areas* – The program of harvest and planting for each year of the project.
- *Labor and Materials* – Includes the costs of seedlings, fertilizer, herbicides, and insurance, as well as planting, pruning, and thinning expenses.
- *Wood Yields* – Predicted wood-product values by log grade, including cost of harvest and transport.
- *Understory Profiles* – Crop or livestock products, including harvested tree products (nuts, pine straw), and how production will change through the tree rotation; effects of canopy closure and windbreak benefits.
- *Environmental Impacts* – Water yield, erosion reduction, carbon sequestration, wildlife.
- *Social Effects* – Family and farm goals, support of the rural community, improved visual aesthetics.

Since agroforestry systems in temperate climates have not been studied through several complete rotations, landowners will work with incomplete data during the evaluation process. Yield data from same-age tree plantations must be adjusted for an agroforestry system. Understory competition for water and nutrients, as well as light effects on both understory and tree edges, should be taken into account when projecting yields and expected market values.

The Missouri Agroforestry Center's excellent publication *Economic Budgeting for Agroforestry Practices* (5) offers step-by-step guidelines for developing multiple enterprise budgets and then combining them into a cash flow plan (see **Further Resources** below). In addition, the more generic ATTRA publication *Evaluating a Rural*

Enterprise can be accessed on the Web at <http://www.attra.org> or obtained in print form by calling ATTRA.

Integrating several enterprises necessarily involves multiple interactions. How will each component affect the other – for better or worse? How can all operations be managed without damage to other parts of the system? Despite every effort to predict, there will be unforeseen consequences. Advantages and disadvantages will become apparent. It is therefore more critical than usual to continually observe what's happening on the site. If, during planning, certain indicators can be identified as early warning signs, better monitoring will result. An alert manager can avoid losses by quickly noticing problems as they occur.



Cattle profits offset walnut establishment costs.

Agroforestry systems, especially for temperate climates, have not traditionally received much attention from either the agricultural or the forestry research communities. Nevertheless, implementing designs using trees and bushes to enhance crop or livestock production, waste management, and natural resource protection is a step toward a permanent, stable agriculture. Farmers have pioneered many of these systems. Each requires a careful initial design adapted to the site and the farm operation, continuous observation, and a commitment to a long timeline. The resulting farmscape will be beautiful as well

as productive, and can be a source of pride for the family and the community.

WHERE TO LOOK FOR MORE INFORMATION

There are a growing number of information resources on agroforestry in temperate climates, easily available to anyone who seeks them.

The Association for Temperate Agroforestry (AFTA) (See the **Further Resources** section below) is the professional organization devoted to agroforestry research, demonstration, and information dissemination in North America. Its quarterly newsletter, *The Temperate Agroforester*, is included as a benefit of paying annual membership dues. In addition, many books on temperate agroforestry are available to members at a discount. AFTA sponsors a biennial international conference where researchers and practitioners gather to learn what is happening in temperate agroforestry throughout North America. The Proceedings from these conferences provide an excellent overview of the field. Proceedings from many of the past conferences are still available. (See AFTA's website or contact AFTA about availability for purchase.) The seventh conference was held in Regina, Saskatchewan, Canada, in August of 2001. When proceedings become available, ordering information will be posted on the AFTA website.

Based in Lincoln, Nebraska, the National Agroforestry Center (NAC) is an interagency venture of the Natural Resources Conservation Service and the USDA Forest Service. The partnership combines the resources of both agencies to develop and apply agroforestry technologies in appropriate conservation and/or production systems for farms, ranches, and communities. NAC publishes *Inside Agroforestry*, a quarterly periodical containing news from the Center as well as information about developments in agroforestry in the U.S. They also offer a number of practical publications, many of which are free. See **Further Resources** below.

ATTRA distributed a recent USDA publication entitled *Building Better Rural Places: Federal Programs for Sustainable Agriculture, Forestry, Conservation and Community Development*. It identifies numerous agencies and programs, some of which

can help plan and fund new agroforestry projects. Although hard copies are no longer available, it is posted on ATTRA's website: <http://www.attra.org/guide>. An update of the electronic version is planned.

Several excellent reference books – both classics and recent publications – are listed below under **Further Resources**, along with many electronic sources of forestry or agroforestry information.

REFERENCES

- 1) Richards, Keith. 1997. Planning for a positive future: This family seeds enterprises that fit their farm vision. Planting Your Farm's Future Series, National Center for Appropriate Technology, Fayetteville, AR. 2 p. <http://www.attra.org/pub/leaflets/planningrs.html>.
- 2) Conservation Trees For Your Farm, Family & Future. No date. The National Arbor Day Foundation. Nebraska City, NE. 10 p.
- 3) Mortimer, John and Bunny Mortimer. 1996. Shelter & Shade: Creating a Healthy and Profitable Environment for Our Livestock with Trees. Green Park Press, Jackson, MS. 161 p.
- 4) Knowles, Leith and Phillip Middlemiss. 1999. Evaluating Agroforestry Options. A Continuing Professional Development course held at Hot Springs, AR, June 12, 1999. June. p. 6.
- 5) Godsey, Larry D. 2000. Economic Budgeting for Agroforestry Practices. Publication UMCA-3-2000. University of Missouri Agroforestry, Columbia, MO. 20 p.

FURTHER RESOURCES

Agroforestry-related organizations:

Association for Temperate Agroforestry (AFTA)

School of Natural Resources
1-30 Agriculture Bldg.
University of Missouri
Columbia, MO 65211

The \$25/year membership fee includes a subscription to The Temperate Agroforester, a quarterly newsletter, as well as discounts on association events and on many agroforestry books ordered through the association.

The National Agroforestry Center

Rocky Mountain Forestry and Range Extension
Station
Univ. of Nebraska East Campus
Lincoln, NE 68583-0822

<http://www.unl.edu/nac>

Offers a free quarterly newsletter, Inside Agroforestry, to anyone who requests it, and many publications on agroforestry practices and products, all at low or no cost.

Association of Consulting Foresters of America

732 N. Washington St., Suite 4-A
Alexandria, VA 22314
(703) 548-0990

<http://acf-foresters.com/>

Forest Landowners Assn.

P.O. Box 450209
Atlanta, GA 31145
(800) 325-2954

<http://www.forestland.org/>

Members receive Forest Landowner Magazine bi-monthly and a Forest Landowner Manual; announcements of the Southern Forestry Conference and other relevant seminars; discount rates on hunt lease liability insurance; access to student scholarships; and tax and policy updates.

National Woodland Owners Assn.

374 Maple East, Suite 310
Vienna, VA 22180
(800) GRO-TREE

e-mail: info@woodlandowners.org
<http://www.woodlandowners.org>

Members receive a quarterly newsletter, National Woodlands, with information on managing woodland, legislative and tax issues, as well as other intermittent publications; a complimentary visit from a certified forester; and access to videos and other publications.

Books:

Agroforestry for Soil Management, 2nd ed. 1997. By Anthony Young. CAB International, New York, NY. 320 p.

Describes benefits of trees in controlling soil erosion, increasing soil fertility, and maintaining soil structure on marginal lands; offers support for agroforestry practices that improve the soil.

Agroforestry for Sustainable Land-Use. 1999. Edited by Daniel Auclair and Christian Dupraz. Kluwer Academic Publishers. 266 p.

Examines the environmental and social conditions that affect the roles and performance of trees in field- and forest-based agricultural production systems.

Agroforestry: Science, Policy and Practice. 1995. Edited by Fergus L. Sinclair. Kluwer Academic Publishers. 296 p.

An attempt to use the results of process-oriented research toward the goal of developing a policy framework to encourage adoption of agroforestry as a sustainable land-use practice.

Design Principles for Farm Forestry. 1997. Anon. RIRDC/LWRRDC/FWPRDC Joint Venture Agroforestry Program. <http://www.mtg.unimelb.edu.au/designbook.htm>. Pub no 97/48. 102 p.

A guide to help farmers create their own agroforestry design. Written around seven basic reasons for planting trees, each chapter provides basic design principles to achieve that objective; each chapter also provides hints at how to adapt a design to capture multiple benefits. Available for downloading at the website, or in hard copy for \$16 from:

RIRDC
Australia
(02) 6272 4819
(02) 6272 5877

Email: publications@rirdc.gov.au
<http://www.rirdc.gov.au>

Enhancing Wildlife Habitats: A Practical Guide for Forest Landowners. 1993. By Scott S. Hobson, John S. Barclay, and Stephen H. Broderick. NRAES-64. Northeast Regional Agricultural Engineering Service, Ithaca, NY. 172 p.

Available for \$25 plus \$4 shipping from:
Northeast Regional Agricultural Engineering Service
152 Riley-Robb Hall
Ithaca, NY 14853-5701.
(607) 255-7654

Forest Farming. 1985. By James Sholto Douglas and Robert A. de J. Hart. 1985. Intermediate Technology Publications, New York, NY. 207 p.

Food production using tree and other forest resources. Out of print. See your librarian or a used bookseller.

Forest Gardening: Cultivating an Edible Landscape. 1996. By Robert Hart. Chelsea Green, White River Junction, VT. 234 p.

Describes how to transform even a small cottage garden into a diverse hospitable habitat for song birds, butterflies, and other wildlife using a wide variety of useful plants, including fruit and nut trees, perennial herbs, and vegetables.

An Introduction to Agroforestry. 1993. By P.K. Ramachandran Nair. Kluwer Academic Publishers (in cooperation with ICRAF). 496 p.

Describes the development, ecological foundations, and status of agroforestry today. Covers technical aspects of the five major agroforestry practices and evaluates each. Socioeconomic factors and the future of agroforestry are also included.

Nontimber Forest Products in the United States. 2002. Edited by Eric Jones, Rebecca McLain, and James Weigand.

Describes the range of products being produced in woodlands, including traditional uses and users of the forest – both commercial and non-commercial; discussion of sustainable management; also policy, economics, and future research needs.

North American Agroforestry: An Integrated Science and Practice. 2000. Edited by H. E. Garrett, W. J. Rietveld, and R.F. Fisher.

Temperate Agroforestry Systems. 1997. Edited by Andrew M. Gordon and Steven M. Newman. CAB International, New York, NY. 288 p.

Design and practice of agroforestry systems based on ecological theory.

Restoration Forestry: An International Guide to Sustainable Forestry Practices. 1997. Edited by Michael Pilarski. 1994. Kivaki Press, Durango, CO. 525 p.

An encyclopedia of sustainable forestry with international scope, including temperate and tropical applications; an important reference book.

The Silvicultural Basis for Agroforestry Systems. 1999. Edited by Mark S. Ashton and Florencia Montagnini. CRC Press. 296 p.

This college-level textbook summarizes the state of current knowledge in the rapidly expanding field of agroforestry.

The Status, Opportunities & Needs for Agroforestry in the United States: A National Report. 1997. Edited by Miles L. Merwin. Association for Temperate Agroforestry. 41 p.

Available for \$6 from AFTA (See contact information listed above).

Temperate Agroforestry Systems. 1997. Edited by Andrew M. Gordon and Steven M. Newman. CAB International, New York, NY. 269 p.

Explores the development of temperate agroforestry systems, concentrating on temperate-zone areas where the greatest advances, adoptions, and modifications have taken place: North and South America, China, Australia, New Zealand, the United Kingdom, and Continental Europe.

Timber Management for Small Woodlands. Katherine M. Layer. Information Bulletin 180. Revised edition. Cornell Cooperative Extension Service, Ithaca, NY. 57 p.

The Theory and Practice of Agroforestry Design. 1998. By Paul A. Wojtkowski. Science Publishers, Inc., Enfield, NH. 282 p.

Focuses on the theory of agroforestry design; not a manual for practitioners.

Tree-Crop Interactions: A Physiological Approach. 1996. Edited by Chin K. Ong and P.A. Huxley. CAB International, New York, NY. 416 p.

Uses quantitative physiological evidence to support the potential role and benefits of agroforestry in sustainable agriculture, showing how the principles of crop physiology can be applied to the understanding of tree-crop interactions.

Tree Crops: A Permanent Agriculture. 1987. By J. Russell Smith. Island Press, Covelo, CA. 408 p.

Visionary classic describing use of temperate-zone trees to produce food for people and livestock without the erosion associated with annual cropping systems.

A Tree for All Reasons: Introduction and Evaluation of Multipurpose Trees for Agroforestry. 1991. By P.J. Wood and J. Burley. ICRAF, Nairobi, Kenya. ISBN: 92 9059 075 0.

Includes chapters on species selection, planning and design, assessment, and areas of research work.

The Woodland Steward, 2nd Ed. 1994. By James R. Fazio. The Woodland Press, Moscow, ID. 211 p.

Woodland management, including inventory and planning; harvesting and improving the woodlot; chapters on Christmas trees, hollies as a business, and maple sugaring.

Woodland Stewardship: A Practical Guide for Midwestern Landowners. 1993. By Melvin J. Baughman, Alvin A. Alm, A. Scott Reed, Thomas G. Eiber, and Charles R. Blinn. Minnesota Extension Service, University of Minnesota, St. Paul, MN. 195 p.

How to take care of woodlands, including inventory, improvement, and protection; harvesting and marketing; managing for wildlife; and tax and financial investment analysis; excellent supporting appendices.

Proceedings:

Proceedings of Past North American Agroforestry Conferences (AFTA)

The biennial North American Agroforestry Conference series, initiated in 1989, has been a forum for researchers, teachers, extensionists, and practitioners to share up-to-date information about temperate agroforestry. The papers and poster abstracts presented at the meeting are collected in a printed proceedings published by the hosting institution. These proceedings provide a wealth of information on a wide range of topics related to agroforestry.

- **Exploring the Opportunities for Agroforestry in Changing Rural Landscapes.** Proceedings of the Fifth North American Agroforestry Conference, August 1997, Ithaca, NY. Edited by Louise Buck and James P. Lassoie. Published in 1997.

Includes an update on institutional and extension developments, the latest research on temperate agroforestry practices, modeling efforts, and multipurpose trees. Available for \$20 (ppd. USA); check payable to Cornell University from:

Dr. Louise Buck
Natural Resources Dept.
Fernow Hall
Cornell University
Ithaca, NY 14853

- **Building a Sustainable Future.** Proceedings of the 4th North American Agroforestry Conference, July 1995, Boise, ID. Edited by John H. Ehrenreich, Dixie L. Ehrenreich, and Harry W. Lee. University of Idaho, Moscow, ID. 200 p. Published in 1996.

Topics covered include: agroforestry potential, biology, and economics of temperate agroforestry systems, and updates on research of agroforestry practices. Available for \$30 to AFTA members; \$35 for nonmembers (ppd., checks payable to College of Forestry, University of Idaho) from:

Dr. John Ehrenreich
College of Forestry, Wildlife, and Range Stations

University of Idaho
Moscow, ID 83844-1135
(208) 885-7600
(208) 885-5878
e-mail: dixie@uidaho.edu

- **Opportunities for Agroforestry in the Temperate Zone Worldwide.** Proceedings of the Third North American Temperate Agroforestry Conference, August 1993, Ames, IA. Edited by Richard C. Schultz and Joe P. Colletti. Published in 1994.

Includes papers presented on agroforestry systems design, biology, and socio-economics. For purchase information, contact:

Richard Schultz
Department of Forestry
249 Bessey Hall
Iowa State University
Ames, IA 50011-1021
(515) 294-7602

- **Proceedings of the Second Conference on Agroforestry in North America.** August 1991, Springfield, MO. Edited By H. E. 'Gene' Garrett. The School of Natural Resources, University of Missouri, Columbia, MO. Published in 1992.

Papers on general biology, wildlife, systems design, pest management, water quality, and social/economic aspects of agroforestry systems. OUT OF PRINT - check your nearest university library.

- **Agroforestry in North America.** Proceedings of the First Conference on Agroforestry in North America, August 1989, Guelph, Ontario. Edited by Peter Williams. Department of Environmental Biology, Ontario Agricultural College, University of Guelph, Guelph, Ontario, Canada.

Covers a wide range of topics on temperate agroforestry applications. Available for \$25 CDN (AFTA members) and \$30 CDN (non-members), checks payable to the University of Guelph, from:

Andrew Gordon
Dept. Of Environmental Biology
University of Guelph
Guelph, Ontario N1G 2W1
Canada

(519) 824-4120, ext. 2415
(519) 837-0442 (Fax)

Other Proceedings of Interest:

Proceedings of the North American Conference on Enterprise Development Through Agroforestry: Farming the Agroforest for Specialty Products. October 1998. Edited by Scott J. Josiah. The Center for Integrated Natural Resources and Agriculture Management, University of Minnesota, St. Paul, MN. 243 p. Published in 1999.

Includes sections on marketing; medicinals and botanicals; handicrafts, specialty woods, and decorative florals; forest-based food products; unique challenges of specialty forest products; and emerging issues in forest farming. Contact CINRAM for ordering information:

The Center for Integrated Natural Resources and Agricultural Management
(CINRAM)

University of Minnesota
115 Green Hall
1530 Cleveland Ave. North
Saint Paul, MN 55108
(612) 624-4299 / 7418 / 4296
(612) 625-5212 FAX

e-mail: CINRAM@umn.edu

<http://www.cnr.umn.edu/FR/CINRAM/home/index.htm>

Agroforestry and Sustainable Systems: Symposium Proceedings. Held in August 1994 in Fort Collins, CO, 1995. Edited by W. J. Rietveld. General Technical Report RM-GTR-261. USDA-Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 276 p.

Topics include: the use of dormant woody planting for slope protection, living snowfences, agroforestry and wildlife, agroforestry-enhanced biodiversity, conservation trees, and a report on the status of agroforestry in five agroclimatic regions of the U.S. Organized and sponsored by the USDA. Out of print. See your librarian for help in obtaining.

Agroforestry in Sustainable Agricultural Systems. 1998. Edited by Louise E. Buck and James P. Lassoie. Lewis Publishers, Inc., Boca Raton, FL. 400 p. ISBN: 1-56670-294-1.

A selection of papers from a June 1997 workshop in Montpellier, France, including what is understood about underlying processes in agroforestry, an exploration of relevant modeling approaches, and descriptions of temperate and Mediterranean systems – both traditional and innovative.

Journals/Periodicals:

Agroforestry Abstracts

Available on the Internet with a fully-searchable 13-year archive of worldwide agroforestry information with weekly updates. Subscription: \$150 regular; \$80 for AFTA members. Free 30-day trial of the on-line version is available.

Agroforestry Systems

International scientific journal that publishes results of original research, critical reviews and short communications on any aspect of agroforestry, including biophysical and socioeconomic aspects. Subscription: \$427 regular; \$60 for AFTA members.

Websites related to agroforestry:

These websites are continually in flux. If they can't be found at the addresses listed, a Web search will assist you in finding their current locations.

National Agroforestry Center's home page

<http://www.unl.edu/nac/>

NAC homepage with links to publications and other excellent materials, including a Specialty Forest Products series.

University of Missouri Center for Agroforestry

<http://agebb.missouri.edu/umca/>

General agroforestry information, publication on budgeting agroforestry practices, and videos on various practices; describes the Center and its staff, provides abstracts of research; excellent links to many related sites.

Forest Landowners Guide to Internet Resources

<http://www.na.fs.fed.us/pubs/misc/ir/index.htm>

Index of on-line publications covering a wide range of topics related to owning and managing woodlands, pubs on special forest products,

riparian buffers and windbreaks, forest tourism, and much more; includes direct on-line links.

The Australia Master Tree Grower Program

<http://www.mtg.unimelb.edu.au>

Resources for practitioners including an on-line publication for farmers, Design Principles for Farm Forestry; spreadsheets and links to other sites.

Farm, Community, and Tree Network (FACT Net)

<http://www.winrock.org/forestry/factnet.htm>

Fact sheets on many nitrogen-fixing trees – many of them tropical. Research reports and past publications are also available.

Forestry and Agroforestry in NRCS (Natural Resources Conservation Service)

<http://www.nhq.nrcs.usda.gov/BCS/forest/agforest.html>

Directory of state and national agroforestry professionals in NRCS; links to other related government agencies and resources; links to forestry professionals; access to videos and slide shows on various woodland management issues.

Resources for Tropical Forestry and Agroforestry

<http://www.agroforester.com/index.html>

Source of The Overstory, a free e-mail journal; although the focus is on tropical regions, there is considerable information relevant to temperate zone agroforestry.

Poplar and Willow home page

<http://poplar2.cfr.washington.edu>

Covers topics related to newly developing short-rotation woody production for energy and other uses.

Websites related to special forest products:

USDA Forest Service – Special Forest Products

<http://www.srs4702.forprod.vt.edu/pubsubj/sfp.htm>

Contains several articles about non-timber forest products.

University of Minnesota site

<http://www.cnr.umn.edu/FR/CINRAM/home/>
Site to order the Proceedings from the 1998 Specialty Forest Products/Forest Farming Conference and a publication on marketing Special Forest

Forestry with Steve Nix

<http://forestry.miningco.com/cs/alternativeforest>
Several articles about forest products, including charcoal, tree seeds, botanicals, and pine straw.

**Institute for Culture and Ecology's
U.S. Non-timber Forest Product Database**

<http://ifcae.org/ntfp/>
Database lists commercial and non-commercial NTFP species – for identification, development and conservation; can be searched by scientific or common name, product use, parts used, state range, and distribution; also has a searchable bibliographic and Internet links database.

WoodWeb

<http://www.woodweb.com/Home.html>
Woodworking industry homepage with information on lumber sales, furniture and cabinet-making, business, and many other topics related to this industry.

By **Alice Beetz**
NCAT Agriculture Specialist

Edited by Richard Earles
Formatted by Cynthia Arnold

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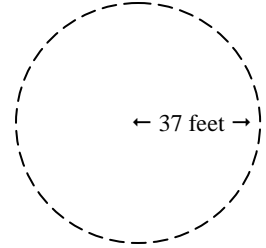
The electronic version of **Agroforestry Overview** is located at:
HTML
<http://www.attra.ncat.org/attra-pub/agroforestry.html>
PDF
<http://www.attra.ncat.org/attra-pub/PDF/agrofor.pdf>

IP155



Estimating Firewood from Standing Trees

1. Choose an area that is representative of where you will be getting firewood.
2. Pick and mark a point to begin your measurements.
3. Measure a distance of 37 feet (using a rope or tape) from the point out. Repeat this procedure several times until you have created an imaginary circle around your point. This circle will be 74 feet in diameter and will represent 1/10th of an acre. (one acre equals 43560 square feet)
4. Measure the diameter (at 4 ½ feet about the ground) of each tree that you would harvest for firewood that is within the circle.
5. Refer to the table to tell you approximately how much each tree will yield in cords.
6. Add the yield of each tree to get a total volume in the sample circle.
7. Multiply the total by ten. This will give you the volume of firewood available on a per acre basis.
8. Repeat the procedure on a number of different plots to give you an average amount available.
9. The table can also be used to keep a running tally of how much you're cutting rather than waiting until the wood is all stacked.



Tree Diameter at 4 ½ feet	Number of Trees to Make a Cord	Number of Cords Per Tree
5"	50	.02
6"	20	.05
7"	12	.08
8"	8	.12
9"	6	.17
10"	5	.21
11"	4	.25
12"	3.5	.30
14"	2.5	.40
16"	2	.50
18"	1.5	.65
22"	1	1.00

Assume 4 inch top diameter

(Based on research by Gevorkiantz and Olsen 1955)

Example:

In a representative sample plot (74 foot diameter circle) you count the following.

3 trees 5" diameter (3 x .02 cords/tree) = .06 cords
 2 trees 8" diameter (2 x .12 cords/tree) = .24 cords
 1 tree 10" diameter (1 x .21 cords/tree) = .21 cords
 1 tree 12" diameter (1 x .30 cords/tree) = .30 cords

7 trees TOTAL = .81 cords

Firewood available per acre = 10 x .81 cords = 8.1 cords per acre.

Stand Management



Fuelwood Management:

Opportunities and options

K. Puettmann and D.E. Hibbs

Heating is one of the oldest uses of wood. Even today, fuelwood is a main product of the forests in many parts of the world. With the expected increase in fossil energy prices, have you considered fuelwood as an option for your forest land?

Fuelwood harvesting can not only yield an income but also improve the quality of your woodlot at the same time. It can pay for the cost of removing undesirable trees.

However, taken too far, wood gathering and fuelwood cutting can degrade a woodlot. To get the most out of your woodlot requires planning and management.

This publication will help you decide where and how to manage for fuelwood. It will help you make decisions needed to manage your woodlot productively and efficiently.

We'll explain first the various situations in which fuelwood management is a viable option. This will help you decide whether fuelwood management is for you.

Klaus Puettmann, former research associate, Department of Forest Science, and David E. Hibbs, Extension hardwood silviculture specialist, Oregon State University.

Next, we describe several different management strategies so you can select the best strategy for your situation.

The last section deals with marketing of fuelwood. Here, we review different marketing options and address questions concerning liability and taxation.

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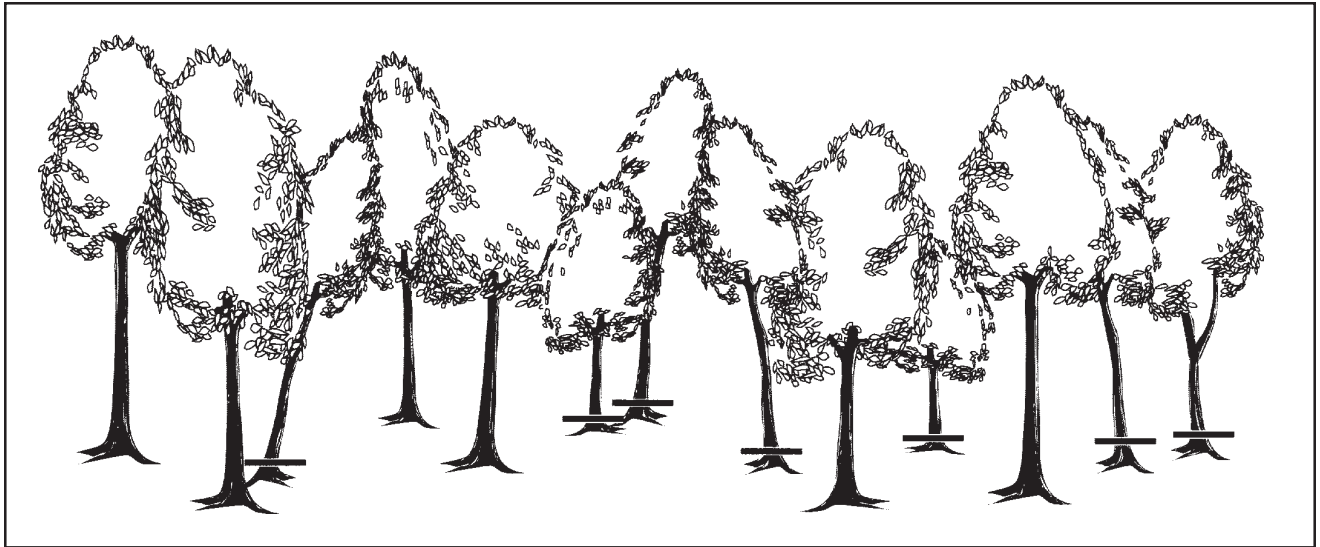


Figure 1.—Early thinning may not yield saw-log products. However, the trees may be salable as firewood. (Trees to be thinned are shown with the slash mark at the base.)

Management situations

There are a number of possible situations that suggest fuelwood as a potential product from your woodlot. They can be grouped into two categories:

1. *Fuelwood as a secondary product.*
Even if your goal is saw and veneer logs, there's an opportunity to increase your revenues through firewood sales. Thinnings from young stands, damaged or crooked trees, or logging slash might be a source of firewood.
2. *Fuelwood as a primary product.*
Your woodlot currently doesn't allow high quality timber production because of drought, disease, soil conditions, or lack of proper management in the past. Firewood management can be done fairly extensively and, therefore, can be a profitable option on sites where timber production doesn't pay. Alternatively, it can make the conversion to a productive timber stand feasible.

Fuelwood as a secondary product

When your primary management goal is saw or veneer timber production, you have to apply intermediate treat-

ments, like thinnings, cleaning, or salvage cuts. Many of these treatments yield little or no marketable timber.

Because of lack of time or money, these treatments frequently don't get done at all or not at the right time. If you can use or sell at least part of the cut and otherwise unmarketable wood as fuelwood, you may be able to make the treatments affordable or even profitable.

We'll describe the most common situations in which you should consider fuelwood harvest: precommercial thinnings, cleaning and improvement cuts, salvage cuts, and logging slash.

Whether the additional work to use or sell the fuelwood is offset by the return from fuelwood sales depends on your special marketing situation. For more information about this topic, see "Marketing" (page 6).

Precommercial thinning

A thinning in which the removed trees are too small to be sold as timber is called a *precommercial thinning*. As plantations and natural stands grow, trees will compete with each other, and the stands become overstocked.

Overstocking results in reduced tree growth, low vigor, and tree death. To avoid this growth loss, you have to thin—that is, remove some trees to give the remaining (crop) trees more growing space (figure 1).

Precommercial thinning is an expensive but necessary operation to ensure quality timber production.

Instead of leaving them to rot, you can remove the cut trees and sell them as fuelwood to help pay for the cost of thinning.

Remember to leave pieces less than 2 inches in diameter. This allows most of the plant's nutrients to be recycled into the soil.

Cleaning and improvement cut

Cutting trees to improve species composition and stand quality in sapling stage and older stands are called *cleaning* and *improvement cuts*.

Most stands are a mixture of crop species, perhaps Douglas-fir, and a less desired species, like black oak or maple. Removing not only the oak and maple, but also the low quality Douglas-fir, will turn these woodlots into healthy, growing stands for timber production.

The cut trees may be too small or crooked to be sold to a saw mill (figure 2), but their use as firewood can make the stand improvement a profitable operation. You may want to leave some trees with low commercial value to enhance plant and wildlife diversity.

Salvage

Trees in your woodlot have been damaged by storm, frost, snow, or insects. Not only may many years of work and investment be lost but also the damage may create a potential for fire hazard or the buildup of insect pests.

Because of low quality, small piece size, or small total amount of wood, the only profitable way to use the damaged wood might be as fuelwood.

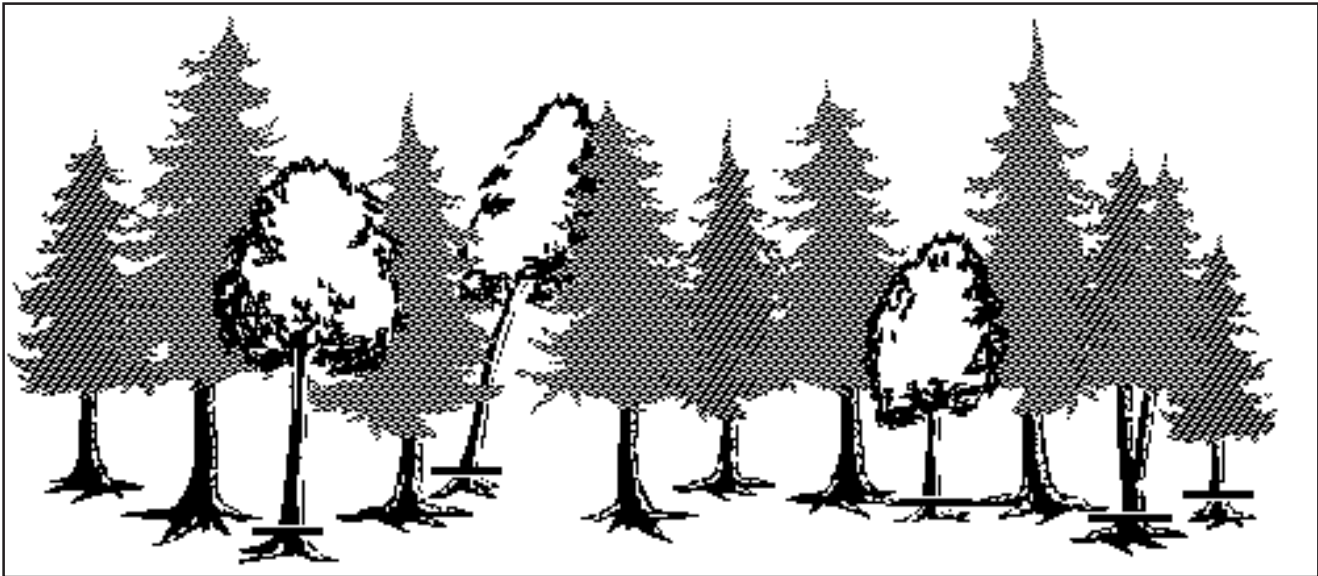


Figure 2.—Removing low value species or trees for firewood increases stand value. This is an improved cut.

Slash

Even in a profitable timber harvesting operation, there's room for increasing your revenue. The logging slash could be used as fuelwood. Tops, larger branches, and low quality parts of the stem, which would otherwise be left or piled and burned, can add up to a substantial amount of fuelwood.

For example, a typical conifer tree contains only 70% of its wood in the trunk; 10% is in the top or the branches. Using this "waste" improves the profit from the harvest—but remember to leave pieces less than 2 inches in diameter.

All these situations are treatments that can be part of high quality timber production. With relatively little cost, perhaps for supervising firewood cutters, you can considerably improve the profitability of these operations.

For more information on thinning, see EC 1183, *Managing Hardwood Stands for Timber Production*, and PNW 184, *Thinning: An Important Timber Management Tool*.

Fuelwood as a main product

There are several situations where fuelwood can be the main product of forest management. We'll describe three: a stand in poor condition, a tree nurse crop, and low quality sites.

Poor stand condition

If a stand is currently in a condition in which high value timber production

is impossible, fuelwood management may be the only viable option to get some revenue from your land. The quality of the stems may be very poor or, alternatively, the stand might consist mostly of an "unmarketable" species.

A thinning or cleaning can provide firewood and give the remaining trees more room to grow. When all the trees have grown to the desired size, you can harvest them and sell or use them as fuelwood. Then reforest with a high value, timber-producing species. EC 1186, *Converting Western Oregon Red Alder Stands to Productive Conifer Forests*, discusses this option for stands of red alder.

Nurse crop

When your regeneration of crop trees fails because of frost or heat stress, a nurse crop can provide the cover necessary to allow plantation establishment.

This nurse crop is normally a frost-hardy or drought-tolerant species. It might not be suitable for high quality timber, but you could very well use it as fuelwood. For example, Pacific madrone might be used as a nurse crop for Douglas-fir on hot, dry slopes. We'll discuss how to choose a proper species in the next section.

Low site quality

Some sites in your woodlot may simply be unsuitable for producing high value timber. Temperature (too high or too low), water (too much or too little), or nutrients (low or

unbalanced) can be a limiting factor for species selection or management.

Nontraditional timber species, such as Pacific madrone, may be your only choice if you want to use your land for wood production. Managing for fuelwood can be done extensively and, therefore, still pay off on these marginal sites.

Many low quality sites already support a stand of hardwoods that will sprout when cut. It may be more profitable to manage these stands for firewood under the coppice system (see page 4) than convert to conifers.

To determine whether your effort is worth the money, see EC 1146, *Forestry Financial Analysis I: An Introduction for Landowners*, and EC 1147, *Forestry Financial Analysis II: Worksheets for How-To-Do-It*.

Which species to choose

After you've decided that you want to concentrate on fuelwood management, the most important question is which species to choose for stand regeneration. The most important factors in matching the species to your location are:

- the site conditions like temperature, summer moisture, and drainage, and

Table 1.—*Characteristics of hardwood species^a*

Species	Region ^b	Heating value	Moisture requirement	Early growth rate		Shade tolerance
				Seedlings	Sprouts	
Ash	Valley bottoms	med.	high-stagnant	mod.	mod.	intol.
Aspen	Eastside	low	med.	mod.	fast	intol.
Bigleaf maple	CR, low Casc.	high-med.	mod.	very fast	mod.	tol.
Black oak	SW	high	low	slow	mod.	med. intol.
Cottonwood	Valley bottoms	low	high,moving	mod.	very fast	intol.
Madrone	SW, WV	med.	low	slow	fast	med. tol.
Red alder	CR, low Casc.	med.-low	high	very fast	very fast	intol.
Tanoak	SW	high-med.	mid-high	slow	fast	tol.
White oak	WV	high	low-mid	slow	mod.	med. intol.

^amed. = medium, mod. = moderate, tol. = tolerant, intol. = intolerant

^bCasc. = Cascades, CR = Coast Range, SW = Southwest Oregon, WV = Willamette Valley.

- species characteristics like growth potential, disease problems, and heating values.

You can get clues for species selection by looking at species already growing on or near the site. Look for their growth and signs of diseases or problems like windthrow or root rot. Be especially careful when you introduce a new species to your site.

Important characteristics of most hardwood species used as fuelwood are listed in table 1 at the top of the page.

Western Oregon grows many other hardwoods in addition to those described in table 1. Most are abundant in local areas.

The sprouters, like Pacific madrone, myrtle, chinkapin, and canyon live oak, are most adaptable to fuelwood management.

New introduced exotics like hybrid pines—for example, Knobcone-Monterey pine (see EC 1193, *Using Knobcone-Monterey Hybrid Pine in Western Oregon*) also show some promise.

All conifer species can be used for fuelwood production (table 2). However, their major use is for timber production. In most conifer stands, firewood will only be harvested when low quality trees are removed or the stand is thinned.

For more detailed information, see *Silvics of Forest Trees of the United States* and talk to the Extension forestry agent who serves your county.

Harvesting and regeneration strategies

All timber management strategies can be modified to accommodate fuelwood management. Because of their low regeneration costs, the coppice, shelterwood, and seed tree methods are most frequently used for fuelwood production.

Uneven-aged management can provide a continuous firewood supply on a small woodlot. The coppice method is limited to sprouting species; the seed tree and shelterwood methods, and uneven-aged management, involve regeneration from seed and planting.

Coppice method

This is the oldest forest-management practice used by mankind. It's simply the repeated cutting and resprouting of trees. Therefore, it clearly requires a sprouting species (see table 1).

However, the practice can't be carried on indefinitely. After several cutting cycles, sprouting vigor decreases, and the incidence of rot increases. Bigleaf maple, cottonwood, and ash are especially susceptible to rot.

Sprout cutting can be done most of the year. The best harvesting time to start sprouting is during the dormant season. Avoid cutting during the active growth period of June and July.

When you harvest, cut the trees back to the stump with a low, clean, and angled cut, so rainwater can run off (figure 3 on the next page). This reduces the chance of disease entry.

The sprouts have extremely fast initial growth because they start with the root system and food reserves of the parent tree. This rapid growth requires a high nutrient supply. New sprouts do have a higher than average frost sensitivity.

Sprouting usually results in a jungle of stems. After the second or third growing season, remove some stems from the stumps. This provides more space and resources for the remaining stems and enhances their growth. Unthinned sprouts will also produce fuelwood, but they'll require more time to reach a usable size.

When you thin sprouts, leave one sprout for every 6 to 12 inches of circumference (figure 4). The best stems to leave are those that start low on the stump, preferably sprouting from the base. They're less likely to break off the stump or to succumb to the rot present in the old stump.

Table 2.—*Heating values of conifer species*

Species	Heating value
Douglas-fir	med.
Grand fir	low
Hemlock	med.-low
Juniper	med.
Western larch	high-med.
Lodgepole pine	low
Ponderosa pine	med.-low
Western redcedar	med.-low

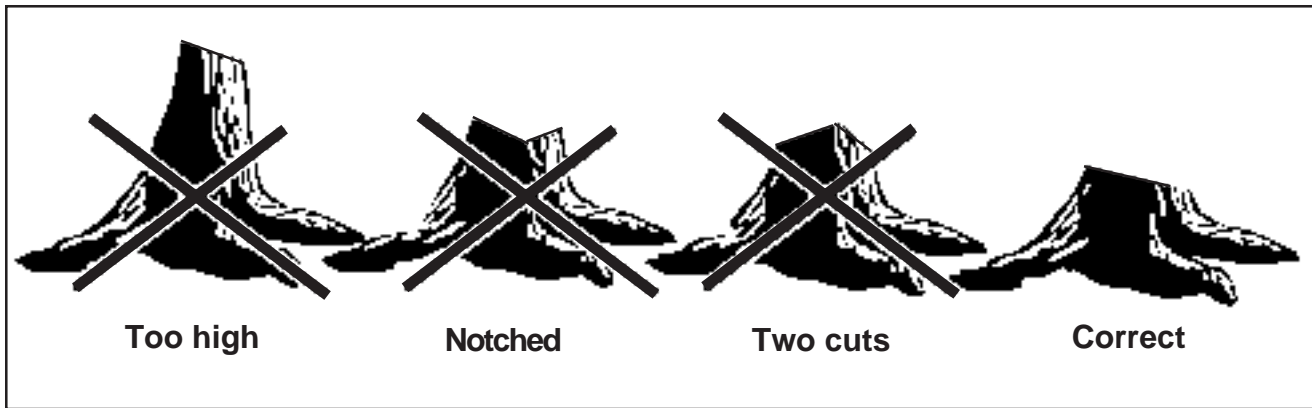


Figure 3.—To encourage sprouting, cut stumps low with a single cut. A slight angle proves water drainage from the stump and can reduce rot.

Younger trees generally sprout more vigorously than older trees. Sprouting of stumps with a diameter less than 10 inches will be vigorous. As stumps get larger than about 18 inches in diameter, sprouting of most species drops dramatically. Bigleaf maple and Pacific madrone are exceptions.

The harvesting cycles in a coppice method are relatively short, 6 to 15 years. Therefore, the wood produced is of small size, 4 to 8 inches in diameter.

Timber and coppice fuelwood production can be combined in a method called *coppice with standards*. In this method, you leave some healthy, good quality sprouts or seedlings through several fuelwood cycles.

These trees, called *standards*, can become high quality timber. This

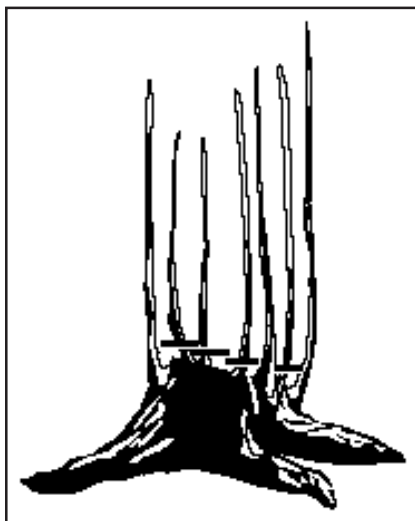


Figure 4.—Cut stumps produce many sprouts. After 2 to 3 years, sprouts should be thinned to leave one sprout per 6 to 12 inches of stump circumference.

allows you to combine both timber production on long rotations and fuelwood production on short rotations on the same piece of land. The standards may also provide esthetic and wildlife benefits.

Seed tree method

As the term implies, this method requires leaving a few trees as a seed source. Three to ten trees per acre are usually sufficient for regenerating a site. Distribute the leave trees evenly over the area; they should have good enough form, vigor, and quality to ensure sufficient, genetically superior seed production.

Vigorous trees are also important to avoid problems of windthrow or sunscald. After 2 to 5 years, when the regeneration is established, you can harvest the seed trees.

Shelterwood method

In this method, the leave trees act both as seed source and as protection or shelter for the seeds and seedlings against adverse temperature and moisture condition. The overstory is removed in two (or more) steps.

In the first step, you remove half to three quarters of the canopy (figure 5a on page 6). This improves seed production and moderates the light and temperature conditions in the understory for improved seed germination, seedling establishment, and growth.

After 2 to 8 years, when a good crop of regeneration is established, remove the rest of the overstory (figure 5b on page 7).

Uneven-aged management

Many conifer stands in east or southwest Oregon have been managed in an uneven-aged fashion. This management applies not only to timber production but also to ensuring a continuous supply of firewood.

Uneven-aged management may be of special interest if your woodlot isn't large enough to contain stands of many different age classes. By selecting individual or small groups of trees for firewood cutting in a yearly or every-2-years cycle, you can ensure stand openings for regeneration as well as sufficient growing space for the residual trees.

Because of the frequent entries, uneven-aged management requires good access to the stands as well as careful harvesting operations. It's easy to damage the residual stand.

Species requirements

Successful implementation of either seed tree system, the shelterwood system, and uneven-aged management requires that you meet the regeneration requirements of the species.

Some species—alder, for instance—require more light than the shelterwood method provides. All species require a reduction in competition from understory shrubs, herbs, and grasses for optimal growth.

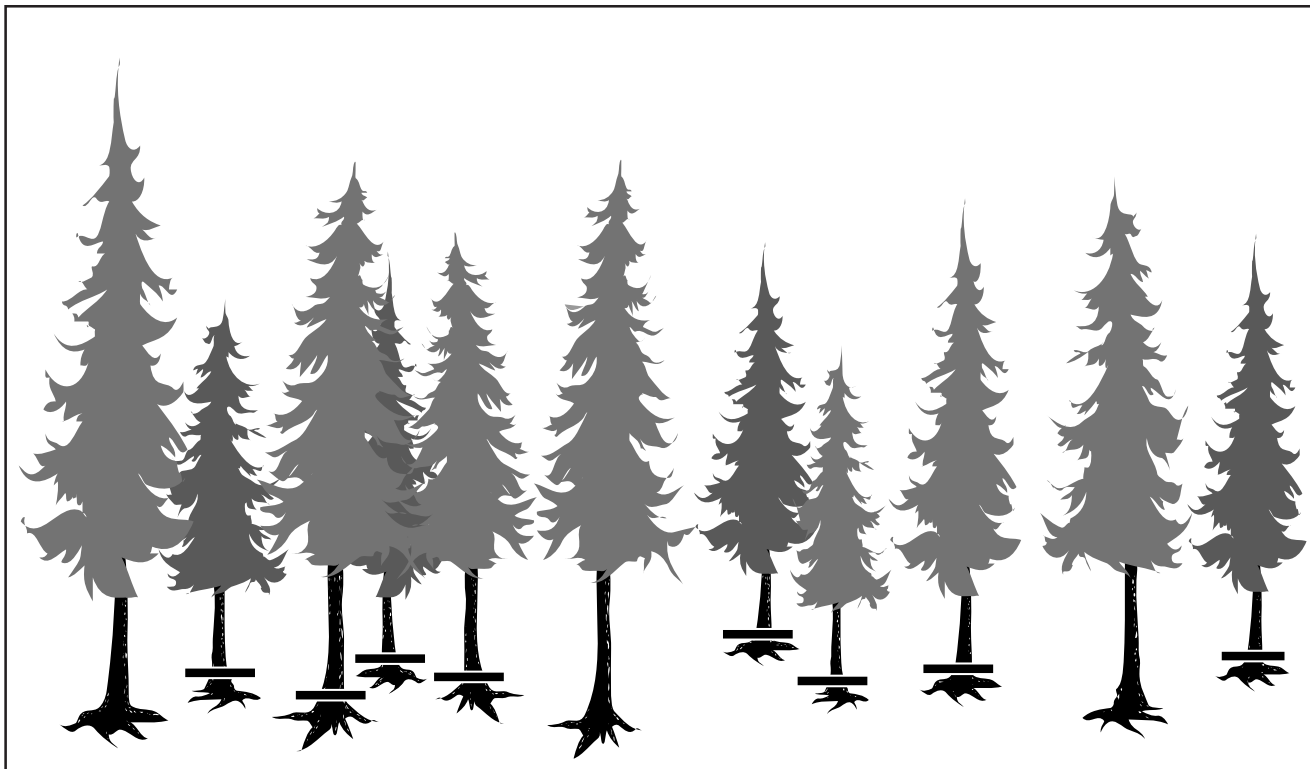


Figure 5a.—In a shelterwood, half to two-thirds of the trees are harvested in the first cut (above). The remaining trees provide seed and shelter for the new stand (see figure 5b at the top of page 7).

Most prefer a mineral soil seed bed for germination. A reduction in competition and exposure of mineral soil can usually be accomplished in the logging process if the need is recognized in advance.

General considerations

Harvesting notice

When you plan to sell firewood or use power-driven equipment (such as a chainsaw) in the harvesting operation, you have to file a harvesting notice with your local Oregon Department of Forestry service forester.

Measurement units

The common unit of sale is the cord, defined as 124 cubic feet of stacked wood (4 x 4 x 8 feet). Because of the air spaces between the pieces of wood, a cord actually contains about 80 cubic feet of solid wood.

There's more solid wood in a cord that contains split wood or a mix of diameters than a cord of uniform diameter pieces. There's more wood in a cord of stove-length pieces than in a stack of 4-foot bolts.

An 8-foot pickup truck bed has space for one-half to two-thirds of a cord. However, when you fill your truck, you need to consider the weight limitations of your vehicle. A cord of green Douglas-fir weighs about 3,000 pounds.

Marketing

Opportunities for marketing your fuelwood are mainly determined by the location of your forest land in relation to the customers. The urban centers provide a concentrated market, high demand, and high prices. Rural areas have a dispersed market and often abundant resources.

Distance to market will determine transportation costs and so affect profitability. Distance may also affect the form of product you can sell. Most residential consumers want split, stove-length wood. If you sell directly to the consumer, you'll have to supply wood of this size. If you're far from the market, it may be more cost-effective to cut and transport bigger pieces to a yard close to the retail market.

Take the time to investigate markets. Look at newspaper ads and

notice boards to determine the current market situation. See EC 1130, *Developing a Marketing Strategy for Woodland Owners: Initial Considerations*, for more information on marketing strategies.

There are three basic marketing options: stumpage sales, stacks of 4- to 8-foot-long wood, called *wood bolts*, on the roadside, and sales of finished firewood products.

Stumpage sales

Stumpage sales are the least work-intensive for the landowner. A contract is drawn between you and the buyer, who is cutting and transporting the wood. You only need to supervise the logging operations. However, your low labor input is reflected in lower prices. Since most consumers don't have professional equipment for logging and transportation, you need a good road system to assure access to the stands.

Keep in mind that the buyers are mainly interested in easily accessible wood and not in proper silvicultural treatments. Be sure to give them clear instructions or mark the cut trees yourself by spray painting or flagging. Sample contracts are available from your Extension forestry agent.

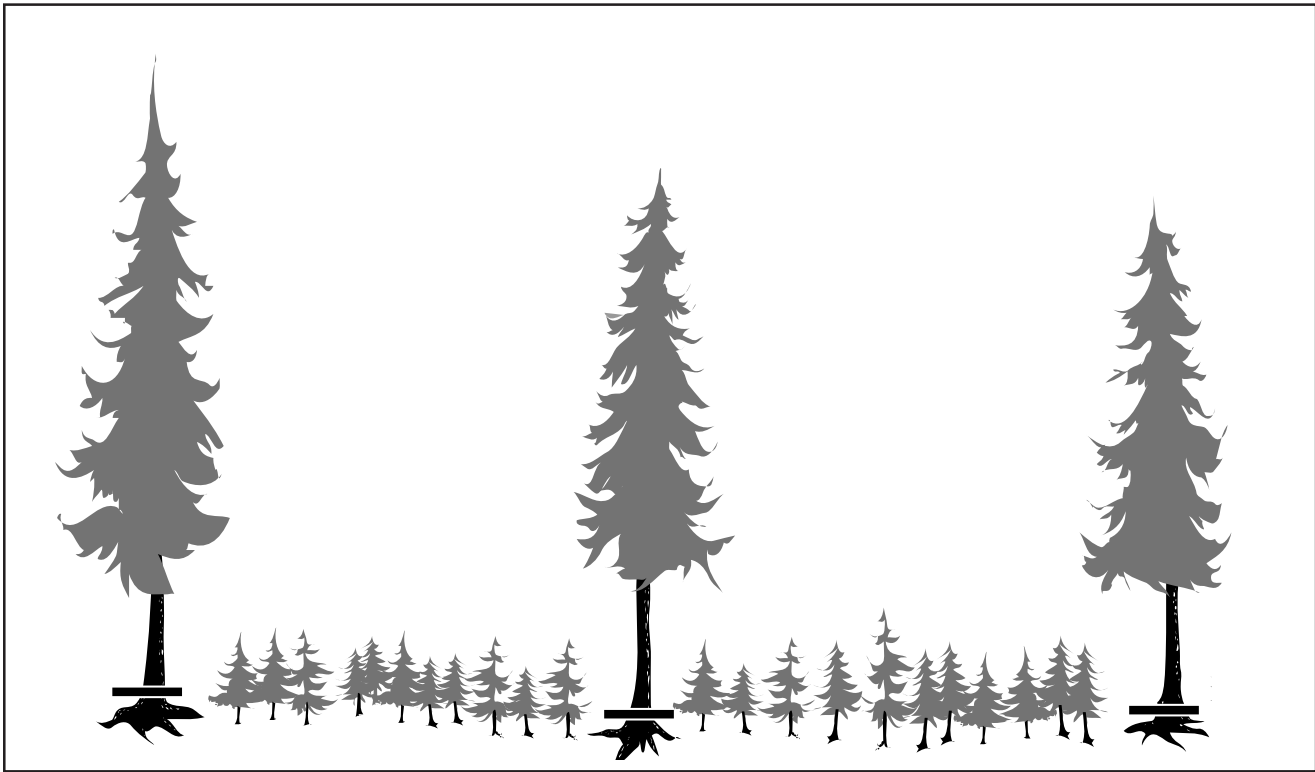


Figure 5b.—Shelterwoods are useful on frost-prone or hot and dry sites because the overstory moderates the environment of the seedlings.

For more information on contracts, see EC 1192, *Contracts for Woodland Owners and Christmas Tree Growers*.

Wood bolts

The second option is to sell fuelwood in wood bolts on the roadside. Wood bolts are stacks of 4- to 8-foot logs. This obviously means more labor for you, but you can demand a higher price for the stacked wood.

You can either do the work yourself or hire a contract logger. Check in the newspaper or consult your Extension forestry agent for available contract loggers.

It may be safer and cheaper to let an experienced logger do the felling, skidding, and bucking. If you have the skill and time, you may choose to do the work yourself to avoid the cost of a logger.

Finished firewood

If you want to sell stove-sized wood, you fell, skid, buck, and split the wood, and transport it to a concentration yard or to the retail customer. Remember: a retail license is required if you set up a retail yard or office.

This is the most labor-intensive option, but you receive the highest prices for your wood. As we explained

under *Wood bolts*, you can either do the work yourself or hire a contractor. If you plan to sell directly to the customer, advertise in the local newspaper or hang signs on bulletin boards.

Plan ahead

In all three of these options, plan ahead by estimating how much wood you can sell or use each year. Having an established clientele base allows you to plan the amount of wood you sell and use each year. Try to match this with the amount of wood cut in stand treatments or to fulfill your financial needs.

Which of the above marketing options fit you best? The main factors to consider are:

- distance to a market,
- the amount of your own time you plan to invest,
- the amount of volume you plan to harvest,
- the equipment you have available, and
- the availability of contract loggers.

Consider all of these factors before you make a decision. You can also use a combination. For example, on easily accessible ground, let the customers

cut the trees themselves. On the less accessible ground, hire a logger for the felling and logging and do the splitting and bucking on the roadside yourself.

Taxation

Harvesting forest products is subject to Oregon and Federal taxes. Consult Oregon's Forest Products Harvest Tax (see EC 1151, *Oregon's Forest Products Harvest Tax*) to determine your tax liability.

Insurance

Finally, in some of these marketing options, you may allow someone else to work on your land. If this is the case, be aware of your personal liability and consult your insurance agent to determine your needs and proper amount of coverage.

If you work yourself, be sure to use safety equipment and follow the safety recommendations of the machine manufacturer.

For more information

In July 1992 the OSU Extension Service publications warehouse was destroyed by fire. We are replacing our supplies. The publications listed may be available in the office of the OSU Extension Service that serves your county. Check with that office for current prices.

You also may call Agricultural Communications at Oregon State University, (503) 737-2513, to learn the availability and current price of the publications.

Cleaves, David A., *Developing a Marketing Strategy for Woodland Owners: Initial Considerations*, Extension Service Circular 1130 (Corvallis, 1984) 75¢.

Elwood, Norman B., *Converting Western Oregon Red Alder Stands to Productive Conifer Forests*, Extension Service Circular 1186 (Corvallis, reprinted 1992) \$2.00.

Elwood, Norman E., and McMahon, Robert O., *Forestry Financial Analysis I: An Introduction for Landowners*, Extension Service Circular 1146 (Corvallis, reprinted 1992) \$1.00.

Elwood, Norman E., and McMahon, Robert O., *Forestry Financial Analysis II: Worksheets for How-to-do-it*, Extension Service Circular 1147 (Corvallis, reprinted 1993) \$4.50.

Emmingham, William H., *Using Knobcones and Monterey Hybrid Pine in Western Oregon*, Extension Service Circular 1193 (Corvallis, reprinted 1993) \$1.50.

Emmingham, W.H., and Elwood, Norman E., *Thinning: An Important Timber Management Tool*, Pacific Northwest Extension Publication PNW 184 (Oregon State University, Corvallis, Reprinted 1992) \$1.00.

Hibbs, David E., *Managing Hardwood Stands for Timber Production*, Extension Service Circular 1183 (Corvallis, reprinted 1993) 75¢.

Mukatis, W.A., and C.F. Sutherland, Jr., *Contracts for Woodland Owners and Christmas Tee Growers*, Oregon State University Extension Service Circular 1192 (Corvallis, reprinted 1992) \$2.00.

Oester, P.T., and W.H. Emmingham, *Using Precommercial Thinning to Enhance Woodland Productivity*, Oregon State University Extension Service Extension Circular 1189 (Corvallis, reprinted 1992). \$1.25.

Sutherland, Charles F., Jr., *Oregon's Forest Products Harvest Tax*, Extension Service Circular 1151 (Corvallis, reprinted 1992) 75¢

Other publications

Fowell, H.A., *Silvics of Forest Trees of the United States*, Agricultural Handbook 271, USDA Forest Service (Washington, DC, 1965).

The Woodland Workbook is a collection of publications prepared by the Oregon State University Extension Service specifically for owners and managers of private, nonindustrial woodlands. The Workbook is organized into separate sections containing information of long-range and day-to-day value for anyone interested in wise management, conservation, and use of woodland properties. It's available in a 3-ring binder with tabbed dividers for each section.

For information about how to order, and for a current list of titles and prices, inquire at the office of the OSU Extension Service that serves your county.

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SAFE **T**IMBER **H**ARVESTING



Prepared by:



UNIVERSITY of NEW HAMPSHIRE
COOPERATIVE EXTENSION

in cooperation with:

NH Timber Harvesting Council
NH Timberland Owners Association
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COOPERATIVE EXTENSION



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PREFACE

This guide is not a substitute for proper Safety Training. It is meant as a reference only.

Safety is the responsibility of everyone and should not be placed solely on either management or employees. Management has the responsibility to provide a safe work environment and to properly train employees. Employees have the responsibility to comply with all rules and regulations issued under OSHA.

This Training Guide was originally published by the Forest Industry Safety and Training Alliance, Inc. (FISTA), Rhinelander, Wisconsin in 1997. It is reprinted with permission from FISTA. It has been reviewed by the Occupational Safety and Health Administration (OSHA) for use in logging training.

The Guide Does Not Necessarily Reflect The Views Or Policies Of The U.S. Department of Labor, Nor Does Mention of Trade Names, Commercial Products, Or Organizations, Constitute An Endorsement Thereof.

In January 1998, New England was hit with an icing event which resulted in 700,000 acres of storm-damaged forest and roadside trees spread across 9 counties. The damage, mostly broken tops and bent over stems, created extremely hazardous conditions for those attempting to salvage timber and clear roadways.

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PROTECTING YOURSELF AND OTHERS

Equip Yourself And Wear The Appropriate **Personal Protective Equipment (PPE)** For Your Job:

Eye Protection
Head Protection
Hearing Protection
Hand Protection
Foot Protection
Leg Protection

- ✓ Handle and carry a chain saw in a manner that protects yourself and others from injury.
- ✓ Mount and dismount equipment using the three-point contact method in order to prevent personal injury.
- ✓ Recognize danger zones by keeping safe distances between others, equipment, and you, during cutting, skidding, decking (piling), and loading operations.
- ✓ Recognize the importance of proper lifting, carrying, and body positioning techniques to avoid back injuries.
- ✓ Recognize symptoms of potentially hazardous occupational diseases such as carpal tunnel syndrome, back injury, hearing loss, and Lyme disease. Understand benefits of **PPE** in relation to these diseases.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

1. Safety helmets **must** be provided to and worn by everyone on the job.
2. Safety pants or chaps **must** be provided to and worn by workers using chain saws even if the use is only occasional.
3. Gloves or mitts **must** be provided to and worn by workers who handle wire rope and chain saws.
4. Safety goggles, safety glasses, or a face screen **must** be provided to and worn by workers when the possibility of eye injury is present.
5. Hearing protection **must** be provided to and used by workers who are exposed to excessive noise, e.g. chain saw operators and skidder operators.
6. OSHA-approved first aid kits **must** be provided to each work crew and be kept readily available.
7. Equipment operators **must** provide and wear waterproof heavy duty logging-style boots. **Chain saw operators must** provide and wear waterproof boots with lug or caulked soles, resistant to chain saw penetration.

NOTE: OSHA requires that items one through six be provided at no cost to the employee.

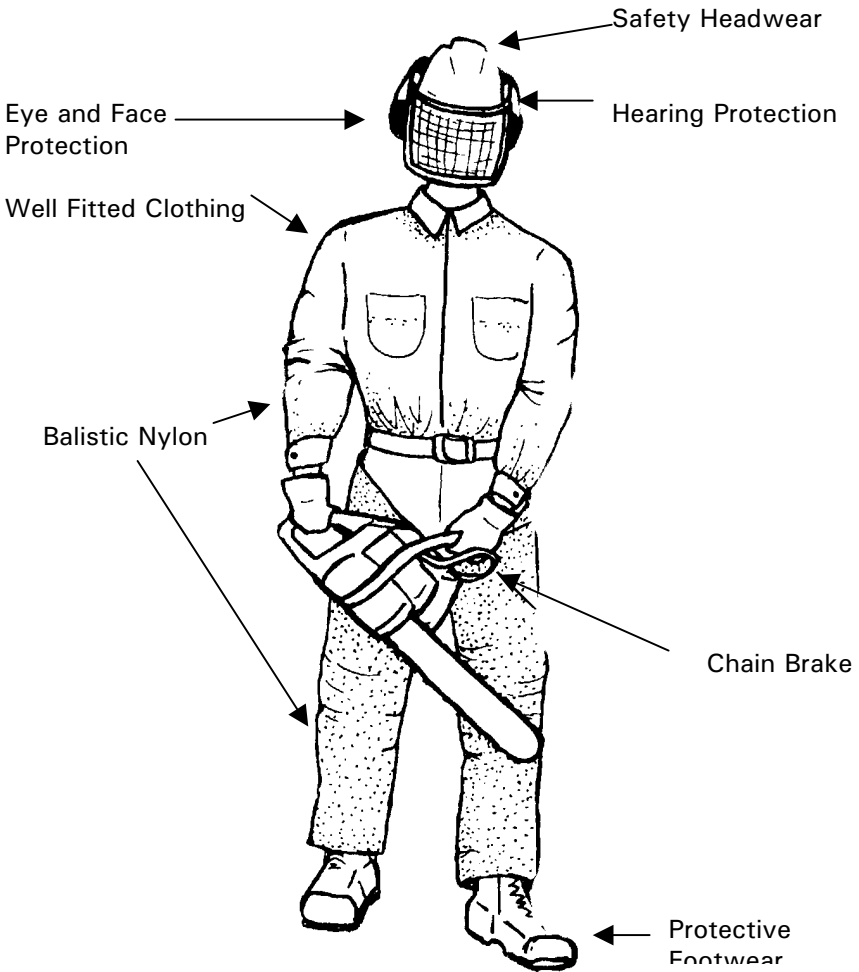
About That New Worker

Was The Worker ...

- 1) told to do the job?
- 2) shown how to do the job?
- 3) observed while doing the work?
- 4) corrected when activities are done unsafe?
- 5) commended for doing well?
- 6) warned of dangers?

Proper job instruction is real accident prevention! Remember that you were once a greenhorn - pass along your experience.

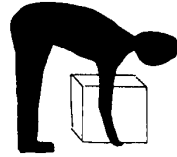
PERSONAL PROTECTIVE EQUIPMENT



INCORRECT LIFTING



With back only



Twisting



High lifting



Load too bulky



Reaching over



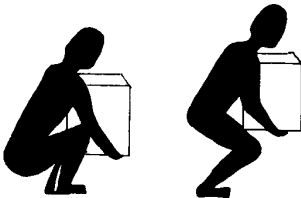
CORRECT LIFTING



Lifting can hurt if done incorrectly. Protect your back by using your legs.



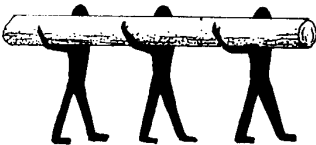
To lift, squat down with knees bent and back straight. Hold the load close to you.



When doing high lifts, lift to waist height, change grip, bend knees, then push up with legs - this avoids body strain.



Be sure you can see where you are going. Get help with big loads.



When team lifting, one man calls the signals and everyone works together.

ALWAYS LIFT GRADUALLY

WORKING IN A SAFE ENVIRONMENT

- Recognize the climatic extremes of wind, heat, cold, wet or dry environments, including their effect on cutting and skidding operations to ensure personal safety and efficient harvesting.
- Establish immediate site safety by eliminating problem trees such as: widow-makers, snags, spears, hang-ups, spring poles, and blowdowns.
- Recognize unstable ground conditions to minimize the effect on cutting and skidding operations and ensure personal safety and efficient harvesting.
- Identify and avoid contact with power lines and cables to ensure site safety.
- Identify, handle, and store hazardous materials such as motor fuel, lubricants, and cleaning solvent, etc., according to the manufacturer's specifications and your hazardous materials plan.
- Follow fire procedures according to company, state, and federal regulations.
- Work as a team member to ensure a safe and efficient operation. Team members must understand and use all company oral, written, and hand signals.

WORKING IN A SAFE ENVIRONMENT

WATCH FOR HUNG-UP TREES



Don't work near hung-up trees. Have these hazards pushed or pulled down by a machine.

ENVIRONMENTAL CONDITIONS

Weather Conditions

All work shall cease and employees shall move to a safe place during electrical storms, periods of high winds (15 MPH for chainsaw work) or other weather conditions that may be dangerous to personnel.

Danger Trees

Hazardous, dead, broken, or rotting trees shall be felled, removed, or avoided. No work will be done in the danger area until a hazard is removed. Set-back trees or hung-up trees shall be marked and removed promptly.

Trees shall be checked for hazardous snow or ice, and precautions taken.

When hazards exist and cannot be avoided, no work shall be done in the danger areas until the hazards are eliminated.

**PLANNING, ORGANIZING AND
PREPARING THE JOBSITE**

- Plan site layout by locating cut boundaries, terrain, and hazards, and determine cut methods to establish the landings, skid trails, and felling patterns.
- Identify hazards including widow-makers, snags, spears, hang-ups, spring poles, and blowdowns. Use chain saws or skidding equipment to clear the ground of underbrush and obstructions where necessary to provide safe access for efficient harvesting.
- Use proper equipment to prepare the landing and main skid trail to promote efficient cutting, skidding, and piling.
- Develop a felling pattern that provides safe access for efficient and productive harvesting by starting the harvest at a point determined by direction to landing, natural lean, terrain, and prevailing wind direction.

PREPARING TO FELL A TREE

STARTING A STRIP

Prepare to fell a tree by determining hazards such as the lean and soundness of the tree, and the speed and direction of the wind. Survey your work area and identify your escape route. Always notch the tree in the direction of fall and proceed with the correct cut for the circumstances.



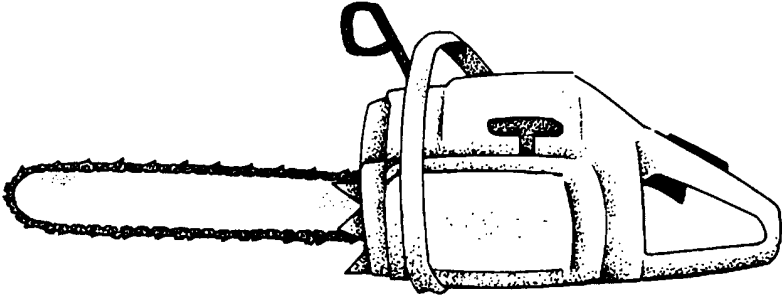
MAINTAINING THE CHAIN SAW

- ***Clean the chain saw*** using proper techniques that ensure optimum performance and safe running condition according to the manufacturer's specifications.
- ***Inspect the chain saw*** for damage, loose screws, worn or defective parts, and proper spark arrester. Repair or replace parts as necessary according to the manufacturer's specifications.
- ***Check guards and safety equipment*** to ensure that they are in place and working.
- ***Fuel and lubricate the chain saw*** according to the manufacturer's specifications for personal protection, to reduce wear, and to ensure optimum and efficient performance. Be sure to use correct gas-to-oil ratio.
- ***Set proper chain tension*** by adjusting it according to manufacturer's specifications to protect the bar and chain from excessive wear and ensure optimum cutting.
- ***Clean and check bar*** regularly for straightness, deburr and dress rails, and lubricate according to the manufacturer's specifications for optimum performance.
- ***Sharpen the chain*** according to the manufacturer's specifications while wearing hand protection and using proper files, gauges, and guides, to ensure optimum cutting and to minimize kickbacks.
- ***Set the motor idle speed*** to ensure that the chain is stationary and the saw can idle.

MAINTAINING THE CHAIN SAW

- ***Start the chain saw with the chain brake engaged***, using one of two methods: 1) Hold the saw firmly on the ground with one hand on the top handlebar, and one foot holding the back handle. 2) The crotch-clamp technique is also acceptable. Secure the back handle of the saw between your legs while holding the top handle firmly.
- ***Test the chain brake*** to ensure that the chain will stop immediately if necessary.
- ***Operate the chain saw*** by keeping both hands on the saw to ensure safe operation and efficient cutting. Keep your thumbs wrapped around the handlebar.
- ***To provide optimum and safe felling***, maintain felling aids such as wedges, axes, and felling levers, by sharpening or replacing them when defective.

CHAIN SAW MAINTENANCE FOR SAFE AND EFFICIENT OPERATION



1. Keep Chains Sharp
2. Use Correct Depth Gauges
3. Keep Bar Grooves Clean And Dressed
4. Keep Proper Chain Tension
5. Use Proper Gas And Oil Mixture
6. Use Proper Chain Oil
7. Use Approved Safety Gas Cans
8. **Daily:**
 - Clean Sprocket Covers And Brake
 - Clean Air Filters
 - Check Nuts And Bolts
 - Check Sprockets
9. **Weekly:**
 - Clean Cylinder Fins
 - Fuel Filter
 - Check Spark Plugs

CHAIN SAW SHARPENING

Loggers are starting to take their saws, saw chain, and guide bars more seriously. They now realize the importance of reducing down-time and increasing productivity through proper maintenance.

By not properly sharpening your chain saw, you will reduce your productivity and increase your bar and chain wear, as well as causing yourself to fatigue.

In addition to the extreme importance of the health and safety factors, there are other considerations that are dependent upon good saw chain sharpening. One cost of operating any piece of equipment is maintenance. Always be concerned with the cost of repairs and replacements; they reduce your net profit which concerns everyone. Proper chain sharpening will increase the life of the chain, bars, power equipment, etc.

TYPES OF CHAINS AND THEIR USES

●Chipper, Micro-Bit Or Round Chain

Use whatever name you want, but all are very similar, if not identical. They are used mostly in .404" to 3/4" Pitch Chains for use with mechanical harvesters and are very popular for cutting hardwoods. These chains are ideal where severe conditions such as dirt and grit exist. In these conditions, dulling is very rapid with other types of chains. They are usually sharpened with a round file or grinder.

●Semi-Chisel Or Micro-Chisel

This chain has a flat top plate and flat side plate with a definite rounded corner at the intersection of these surfaces. This chain type is used more in general applications where cutting

conditions are fairly severe but not extreme. Sharpen with a round file or grinder.

- **Chisel-Type Chain** This chain has a flat top plate and flat side plate with a sharp corner at the intersection of these two surfaces. It is used where production is a prime consideration. This chain is an excellent cutter when used in more ideal tree conditions, and is a favorite of more timber fellers. Best results are produced when cutters are square-ground with a square file or an appropriate grinder.

The previously-mentioned types of chains come with cutters spaced as follows:

1. **STANDARD** (full comp) sequence - one tie strap is positioned between each cutter, alternating right and left, using two drive links for each cutter.



2. **SEMI-SKIP** sequence - cutters alternately have one tie strap between the right and left-handed cutters, then two tie straps between the next right and left cutters, then one tie strap, etc.



3. **FULL-SKIP** sequence - provides two tie straps between each alternating right and left cutter, each supported by three drive links.



Not all chain types are available in the previous sequences; check your dealer for availability. Quite often there will be anti-kick or safety devices installed ahead of the depth gauge incorporated with the tie strap.

The sequence of the cutter position is mostly a personal preference of the saw operator. The standard type provides a smoother cut with less chance of vibration and kick-back, and a good all-around felling, limbing and bucking chain.

Most chains are available in different driver gauges. Standard chains most commonly used are provided in .050", .058", and .063" thicknesses. Some .404" gauge harvester chains are available in .080" gauges while the 3/4" pitch chain is standard at .122" thick on the drivers for obvious reasons.

Depth gauge settings are usually specified by the chain manufacturer and sometimes are stamped on the depth gauge. Their recommendations are generally accepted by the operator.

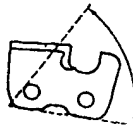
SAW CHAIN SHARPENING ANGLES

Sharpening the saw chain cutters not only requires sharp edges; the angles at which the three (3) surfaces are ground or filed is also of the utmost importance. The surfaces are generally referred to as:

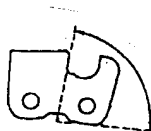
TOP PLATE ANGLE



TOP PLATE CHISEL ANGLE



SIDE PLATE ANGLE



All degrees referred to are given from either the base of the chain or from the side of the chain. The slope of the side or top of the cutter is not a reference point, as these surfaces are angular in themselves.

There are two methods of sharpening chains. The most common method of sharpening is with a hand-held round file. This style, in most cases, will have available file holders and other tools that can help stabilize and provide better accuracy and uniformity to the sharpening operation. The other method of sharpening is by using a grinder equipped with a rotating stone pulled down into the cutter's cutting edge while the cutter is secured in a vise-like rail to hold the cutter in the proper grinding position. This type of grinder is more expensive.

Loggers should follow the chain manufacturer's recommended angle specifications whether using the round file method or a mechanical grinder. Check for the latest information because angular specifications have, in some cases, changed radically in recent years. These changes have been developed in the field and, as a result, the chain performance is much better.

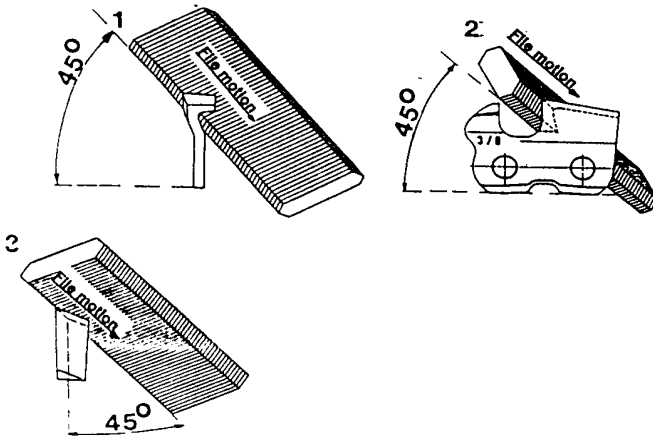
CHISEL BIT CHAIN (SQUARE FILING)

This saw chain is not for everyone. A chisel-bit saw chain is a professionally-classified saw chain. Before using any professional class of saw chain the operator **MUST** be instructed in advanced cutting and maintenance procedures. The reactive forces produced may be higher than low-kick saw chains

CHAIN SAW SHARPENING

The reduced-resistance cutting ability of chisel-bit chains shows noticeably increased cutting speed and smoothness in most wood types. Many loggers are getting excellent results with chisel-bit chains even in dirty wood. They are reducing sharpening frequency compared to that needed on round-ground chisel chains. Users are reducing the top plate angle to decrease the tooth's side movement. The angle iron effect of the channel cut to the point on chisel-bit chains offers the point more support from the underside. This effect decreases the possibility of the point deforming during abrasive conditions.

The round tooth saw chain has many variables: The file size and location, the possibility of hooking the tooth, and the importance of the top angles. With chisel bit filing, the angles are simplified and the file size is the same on all tooth sizes.



CHAIN SAW SAFETY

SAFETY DEVICES

1. All chain saws should have the following mechanical safety features:
 - a. Chain brakes
 - b. Vibration-dampened handle system
 - c. Throttle interlock to prevent accidental engine acceleration
 - d. Chain catcher near clutch housing and throttle handguard
 - e. **Safety features shall not be altered, rendered inoperable, or removed**

2. Accessory safety equipment for chain saw operators:
 - a. Approved safety fuel can
 - b. Appropriate tools to maintain the chain and powerhead
 - c. Two plastic, wood, or aluminum alloy wedges and (felling) bar
 - d. An axe with a blade guard
 - e. Personal first aid kit

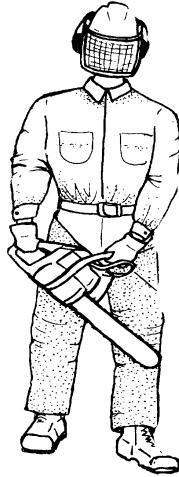
3. Miscellaneous equipment for efficient use of power saws:
 - a. Funnel for fuel and oil
 - b. Extra files and gauges for sharpening the chain
 - c. Spare saw parts to minimize downtime:
 - (1) Spare chain and sprocket
 - (2) Extra guide bar nuts
 - (3) Extra spark plug
 - (4) Extra air filter
 - (5) Extra starter rope and spring
 - (6) Extra chain catcher, spare bar, and bar tip
 - (7) Extra saw wrench
 - d. Fire extinguisher

OPERATING PROCEDURES

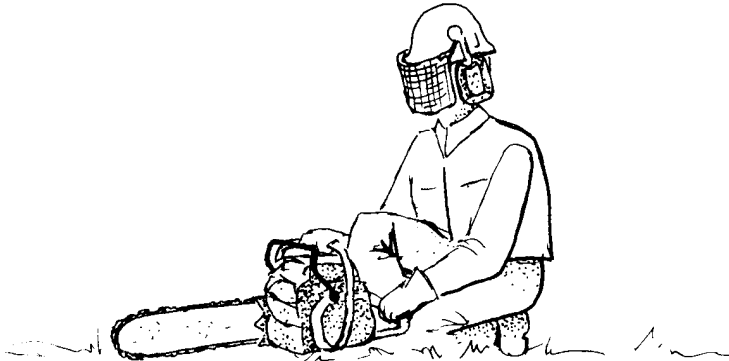
1. Chain saws are involved in more than 50 percent of all woods accidents and should be handled with caution.
2. Hard hats, eye and ear protection, appropriate footwear, and safety pants or chaps shall be worn by saw operators. See page six for a complete list.
3. Always start the saw on flat, level ground, or by using the crotch clamp method; never drop-start or use your knee.
4. When carrying the saw any distance, carry it by the front handle with the motor stopped and the bar to the rear so it can be thrown clear in case of a stumble or fall.
5. Adjust the idling screw so the chain stops and the saw idles for several minutes. Follow the manufacturer's specifications for adjustments.
6. Let the motor cool before refueling. Refuel a minimum of 20 feet from a flame source.
7. Wipe gasoline spills off the motor.
8. Keep a first aid kit and fire extinguisher handy.
9. Keep your thumbs fully encircled but not tight around the handlebars, not resting on top of the handlebars.
10. Hold the saw with your wrists as straight as possible and keep the bar and chain on a plane that is not in line with your body.
11. Stagger your feet in a way that provides for good balance in case of a kickback. Always keep your knees bent and your back straight.

STARTING YOUR SAW

Never Start A Saw On Your Knee Or By Drop-Starting.

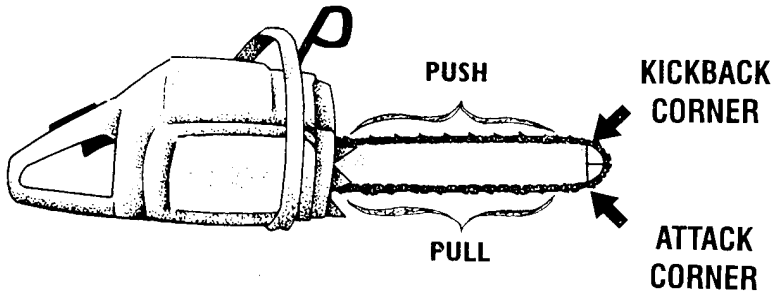


**Always Start Your Saw
On Smooth, Level Ground,
Or By Using The Crotch
Clamp Method.**

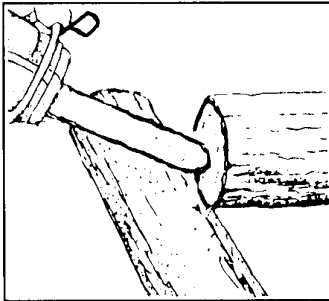


CHAIN SAW KICKBACK

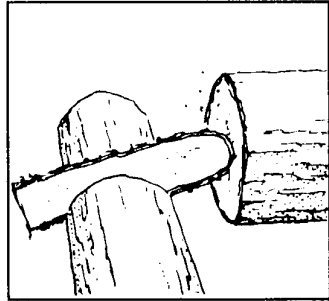
Most chain saw injuries are caused by kickback. Kickback occurs when the kickback corner of the bar strikes an object. To prevent kickback, make certain the tip of the bar is clear for all normal cuts. Make bore cuts using the attack corner of the bar. Start the cut with the lower quadrant of the bar until the wood is on both sides of the tip. Then straighten it out and complete the bore cut. Take a very firm grip on the saw using extreme caution to counteract any kickback reaction.



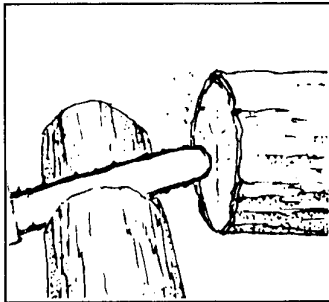
FOUR CAUSES OF KICKBACK



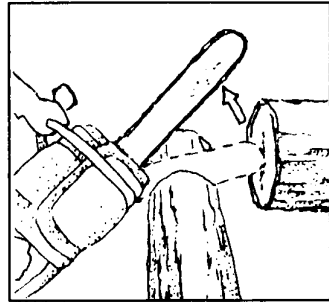
1. The kickback corner of the bar hits an obstruction.



2. The cutting teeth on the chain



3. The chain piles up at the point of contact.

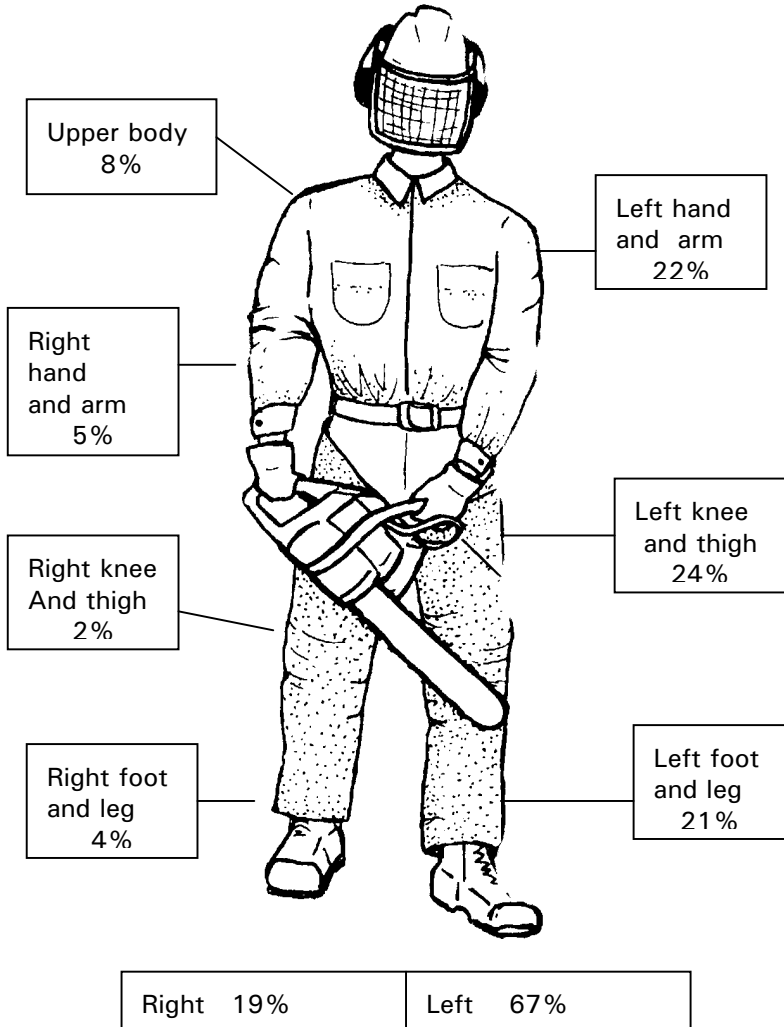


4. Drive force kicks the bar carrying the chain upward in a direction opposite to that in which the chain is being

CHAIN SAW ACCIDENTS

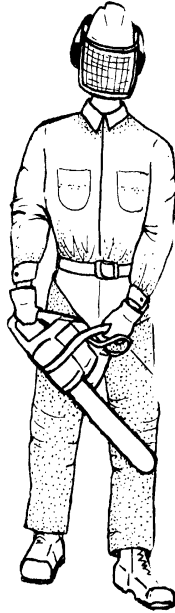
Average Body Contact with Moving Chain
Hitting Points (Average %)

14



KEEP SAW PROPERLY ADJUSTED

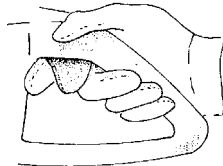
Always keep your fingers back on the handle, not on the trigger. Otherwise, if you fall, you may automatically grab the trigger, causing a serious or fatal injury.



Never carry a saw with a running chain...shut it off or engage the chain brake when carrying for distances greater than 50 feet, or for lesser distances when the terrain and other physical factors make the carrying of a running saw hazardous.

S E T C H A I N B R A K E ! !

***TAKE YOUR FINGERS OFF THE SAW TRIGGER
WHEN MOVING FROM TREE TO TREE.***



FELLING TREES

Determine and develop a safe and efficient felling pattern from visual observation. Take into account such factors as landing area, wind direction, natural lean of trees, and terrain.

Prior to felling trees, identify and eliminate hazards in the felling area such as: widow-makers, snags, spears, hang-ups, spring poles, blowdowns, and unstable ground. This safety check will optimize safety and production.

Observe felling danger zones by keeping a safe distance (two tree lengths or more if necessary) between yourself, others, and equipment.

Prepare the felling area by clearing debris and obstacles from the base of the tree, establishing an escape route, and eliminating potential hazards.

Cut a notch using the "open face" or "undercut" method as described in the **OSHA LOGGING** Standard 29 cfr 1910.266 (g) (2) (iii), making the selection based on tree species, size, lean, location, and safety. Develop a felling pattern to facilitate safe, efficient production.

After giving a warning understood by all personnel, make the appropriate back cut. The back cut on an open face notch should be at the **SAME** level as the notch. Establish the proper hinge wood (length approximately 80% of diameter breast height (DBH), width, approximately 10% DBH) so that direction of fall is controlled and any potential butt kickback is minimized.

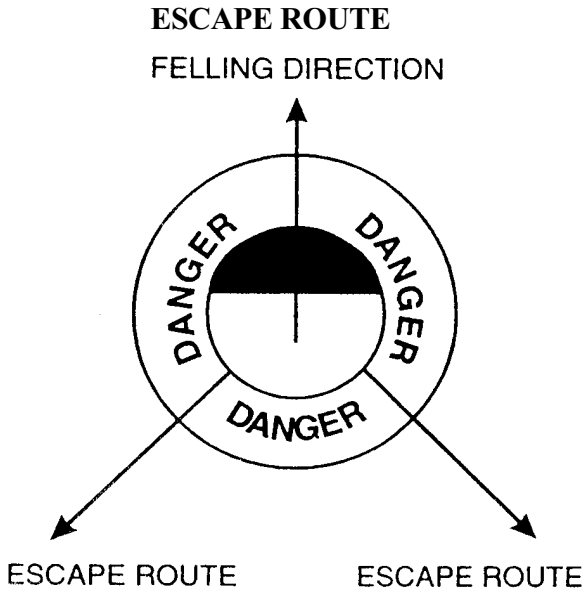
Retreat from a falling tree by using an established escape route 45 degrees to the rear of the intended direction of fall while keeping the tree in view. Establish - Safe side and Hazard side so that you put yourself on the safe side during felling phase of backcut escape to safe side.

PROPER TIMBER FELLING PROCEDURES

1. Cut down all dead snags or stubs first.
2. Always look at the top of the tree for widow-makers, lodged trees, wires, and other hazards. Plan the direction for the fall of the tree. Clear an area around the tree before starting to cut.
3. Prepare a line of retreat 45° away from the line of fall. Be sure you are not hemmed in with underbrush or obstructions.
4. Before starting to cut, make sure no one is closer than two tree lengths away from felling operations.
5. Make a notch on all trees no matter how small the diameter.
6. Give a timely warning yell understood by all employees, just before the back or final cut is started.
7. Never cut a standing tree completely through. Leave sufficient wood between the notch and the back cut for the tree to hinge on; otherwise, you may lose control of the tree and it could kick back.
8. Never leave a lodged or hung tree; always push or pull it down with the aid of a skidder, etc. If it has to be left unattended for any length of time, properly mark it to indicate a danger area.
9. Never cut on days of high wind velocity.
10. Never climb or cut sections out of lodged trees.
11. Never leave a lodged tree, as any vibration from machinery or a sudden wind could bring it down on a crew member or an unsuspecting person.
12. Fell with the lean of the tree whenever possible, and into clear areas.
13. Retreat from a falling tree at a 45° angle away from the direction of fall and at least 20 feet from the tree. If possible, stand behind another tree at the end of your retreat path.

**PROPER FELLING IMPROVES QUALITY, QUANTITY,
AND SAFETY BY REDUCING:**

- ✓ The number of trees falling in the wrong direction
- ✓ Pulled fibers and side scars
- ✓ Damage to the butt log
- ✓ The amount of time spent moving wood to the landing
- ✓ Time spent pushing and pulling trees down
- ✓ Time lost when a chain saw is pinched
- ✓ Injuries from pushing and cutting at the same time
- ✓ The possibility of a tree splitting in a barber chair
- ✓ The number of tree butts kicking back off the stump
- ✓ The possibility of trees being cut almost completely off and not falling



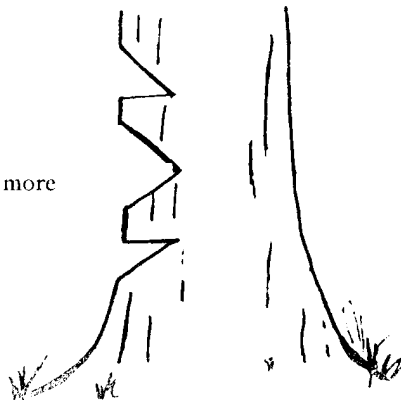
The escape route shall be at a 45° angle away from the falling tree to a distance of at least 20 feet away from the tree.

PROPER NOTCHES

Conventional

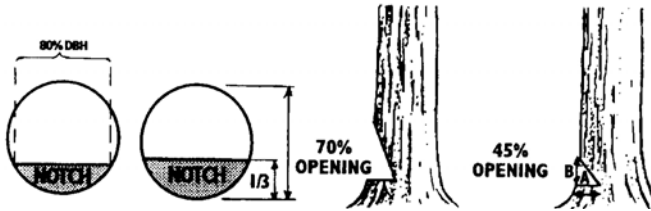
V-Notch
Open-face - 70° or more

Humboldt



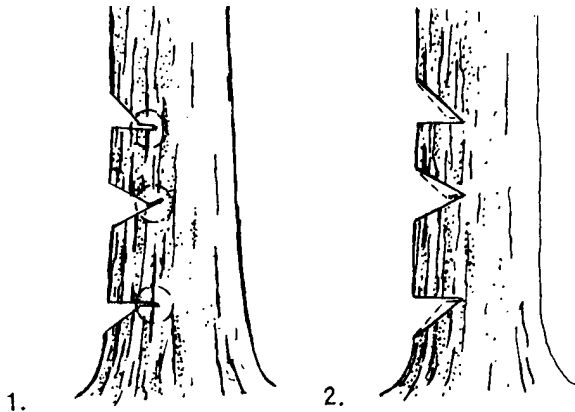
PROPER DIMENSIONS OF NOTCHES

The depth of the notch should be $\frac{1}{3}$ of the tree diameter. The face opening of a notch "A" should be equal to the depth "B."



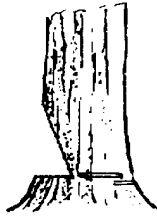
A wide-open face notch is safest, and requires an opening of 70° or more to prevent premature closing of the notch.

THREE TYPICAL IMPROPER NOTCHES

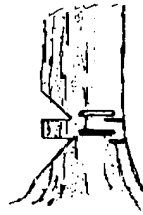


1. Improper notches
2. Portion of notch that must be removed to correct the improper cut

PROPER BACK CUTTING



**OPEN FACE NOTCH
BACK CUT SAME LEVEL
AS NOTCH**



**CONVENTIONAL & HUMBOLDT
BACK CUT NOTCH
SLIGHTLY ABOVE NOTCH**

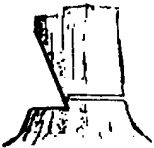
OPEN-FACE NOTCH (70° OR MORE)

Bore cut to establish a hinge and cut toward the back of the tree. Stop the cut leaving enough holding wood on the back side of the tree. Then, release the tree from the back side with a cut below the bore cut.

Hinge or holding wood of sufficient length and width is required to control the tree when falling. The bore (back) cut must be made at the same level as the notch to increase hinge strength. This technique is considered the safest method to fell trees.

RESULTS OF IMPROPER BACK CUTTING

1. Back cut too deep (inadequate hinge)



The hinge will break almost immediately, resulting in inaccurate felling and damage to the bar or saw.

2. Back cut too high above the notch



This highly increases the chance the hinge will break, allowing loss of control of the felling of the tree. It also produces a low quality butt.

3. Back cut below the notch



The same problems exist with this technique as with cutting above the notch. Bypassing the cutting of the notch will reduce hingewood strength and will allow the tree to freefall without control.

4. Sloping back cut



This cut lessens the chance of meeting the notch or leaves an inaccurate hinge producing low quality butt.

5. Angle-back cut with inadequate notch



With no notch directional felling is greatly reduced. This cut produces loss of felling control, low quality butt, and greatly increases the chance of barber chairing.

FELLING PROBLEM TREES

Some trees present special problems in felling:

1. Trees that side scar easily (such as ash)
2. Larger trees - light leaners or heavy tops
3. Heavy leaners
4. Felling trees against the natural lean



NOTE

Several of the following techniques may or may not require shallow side-cutting at the corners of the notch when cutting grade logs. Side-cutting is used on leaners to stop barber chairing and is often used on straight-grained trees such as oak and ash. *Side-cutting of log timber is a must!* This procedure will help reduce side scarring and fiber pull of the butt log; however, it also will reduce the strength of the holding wood or hinge.

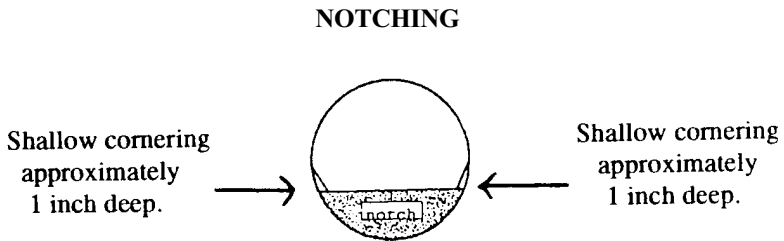
***ALL OF THESE TECHNIQUES
REQUIRE
ADVANCED ABILITIES***

TREES THAT SIDE SCAR EASILY

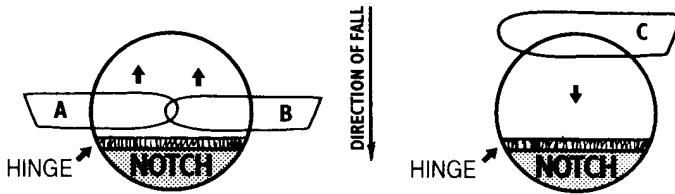
To prevent side scarring in standard felling, the sides of the hinge between the notch and the back cut are sawn before making the back cut.

As the tree falls, the stronger, more flexible fibers do not break when the notch closes.

Instead of breaking with the hinge, strips along the side of the tree rip off the butt log, resulting in side scars.



Method To Use When The Tree Diameter Is Greater Than The Length Of The Chain Saw Bar, But Not More Than Twice The Length Of The Bar



BORING TECHNIQUE

1. The notch is made in the normal manner and the boring cut is **begun using the lower quadrant of the bar tip** starting on the side with the lean of the tree.
2. Once the wood is on both sides of the bar tip, the saw is straightened and the bore is completed just beyond the halfway point of the tree's diameter. This action will allow an overlap when the bore cut is completed from the opposite side of the tree.
3. If the tree has a heavy forward lean, bore in from both sides to establish the hinge. Then cut to the back leaving support wood. Pull the saw out, then release the tree from the backside.

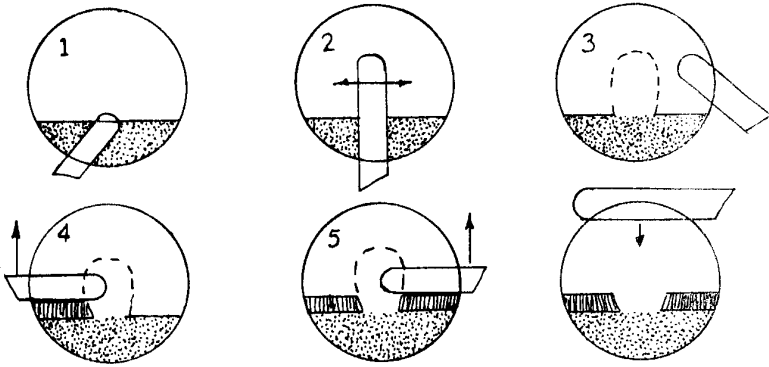


If boring is done incorrectly there is an increased chance of kickback; **use extreme caution.**

CAUTION

When using this technique, the saw needs to be running at maximum RPM's and the chain needs to be properly sharpened. Professional training is advised so that this technique can be properly utilized.

**Method To Use When The Tree Diameter Is Greater Than Two Times
The Chain Saw Bar Length**



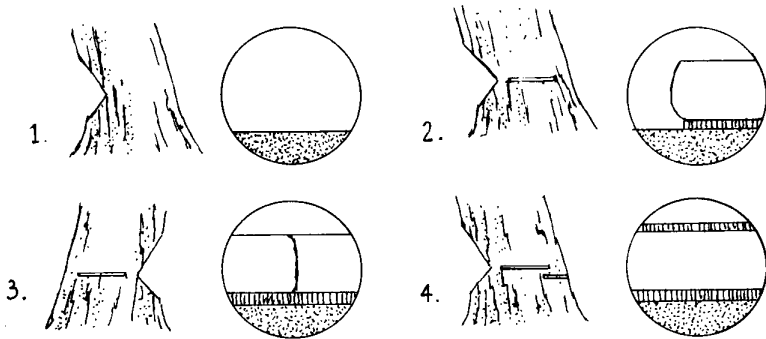
BORING TECHNIQUE

1. The notch is made in the normal manner. A **bore cut is made in the center of the notch using the lower quadrant of the bar tip.**
2. Cut out as much wood as needed so the bar will reach from both sides. Remove the saw.
3. Start a bore cut at the normal level for a back cut, again using the lower quadrant of the bar.
4. Bore straight in, leaving enough hinge wood for the size of the tree. Walk the saw around, cutting approximately half the tree. Repeat the procedure on the opposite side, leaving sufficient holding wood in back.
5. Use a release cut from the back side.

CAUTION

This is a very professional type of felling! A large diameter tree may be left standing until a cutter can use a larger saw with a longer bar. Again, professional training is recommended for this technique.

HEAVY LEANERS



BORING TECHNIQUES

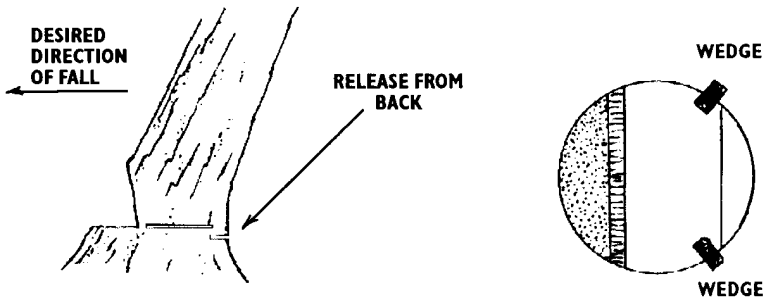
!!! CAUTION !!!

This is a very professional type of felling. If you are not comfortable cutting these trees--DON'T DO IT!

1. Begin by making an open-face notch (70° or more); hinge length should be 80% DBH (or longer if necessary). For example, a 10" DBH tree should have a hinge length of at least 8".
2. At the same plane as the notch, bore out the tree from the hinge wood back, while leaving sufficient holding wood at the back of the tree. Always start boring with the lower part of the bar tip. This is considered the safest felling technique.
3. The same boring procedure is then performed on the other side of the tree, ensuring that the two boring cuts meet. Omit this step if the tree is small enough for the saw bar to reach through the tree in one cut.
4. A final horizontal back-cut is made below the boring cut. The holding wood at the back severs and the tree falls, guided by the hinge. Always start boring with the lower part of the bar tip.

FELLING AGAINST THE NATURAL LEAN

A large tree may be felled against its natural lean by using the boring technique. Use the open-face notch and bore cut the tree to establish the hinge. **DO NOT CUT OUT THE BACK.** Allow enough backwood to keep the tree secure. Remove the saw from the bore cut and insert wedges tightly into it. Release the tree from the back. Complete the technique by wedging the tree over. *This technique is for experienced cutters only.*



Felling against the natural lean may be necessary to:

- Avoid falling into other trees
- Place the tree in the desired direction
- Prevent a hang-up
- Avoid breakage
- Avoid disturbing the felling pattern
- Avoid falling on fences, across property lines, etc.

LIMBING AND BUCKING

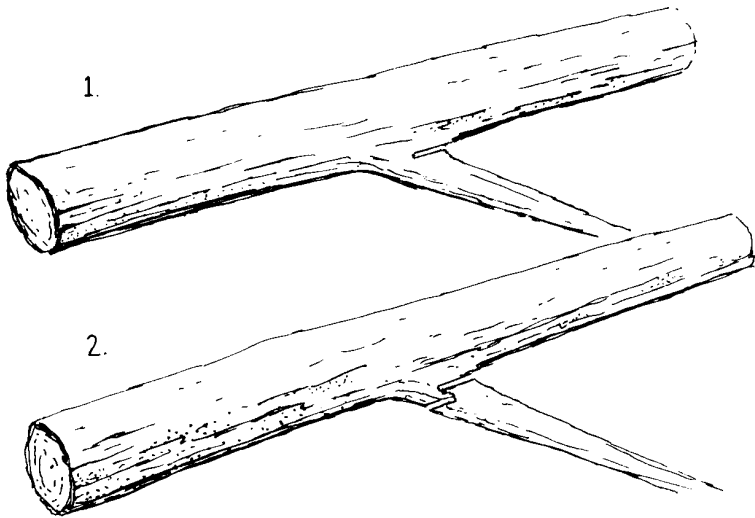
LIMBING AND TOPPING TREES

1. Identify hazards such as spring poles, compression and tension stress points, holes, and hanging limbs and/or tops. Chain saws and skidding equipment or related tools can minimize or eliminate problems such as saw kickback, limb/tree/springpole kickback, and tree roll.
2. Move back into the felling area to begin limbing and topping only after all debris produced by the falling tree is settled, and all potential hazards are eliminated.
3. Cut limbs and tops from felled trees using balanced footing, body position, and safe saw handling methods in accordance with utilization standards.

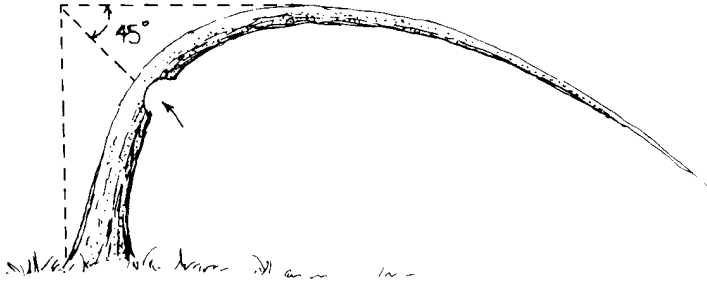
SAFETY INSTRUCTIONS FOR LIMBING

1. Make sure your footing is sound; keep your balance.
2. Start limbing from the butt end of the tree and work toward the top.
3. Always stay on the uphill side of the tree.
4. Always limb from the ground; do not walk on the tree.
5. When possible, stand with your feet in the clear, and limb from the left side of the tree.
6. Make sure the saw bar is on the opposite side of the tree before moving forward. Do not move when the saw is on your side of the tree.
7. To prevent kickbacks, do not limb with the kickback corner of the saw. Make sure the saw is at full speed before cutting a limb.
8. Carefully cut spring poles from the underside to relieve the tension first, then cut it off.
9. Cut supporting limbs last using extreme caution as the log may roll.
10. Use the top of the bar when possible to avoid cutting toward your feet and legs.

11. When cutting large limbs, be alert for the chain binding and kicking back. Use the limb lock technique.
12. Keep a minimum of two tree lengths away from the feller and falling trees.
13. When cutting limbs under tension, use a limb lock technique. Relieve pressure on the limb by making the first cut on the tension side. The second cut should slightly bypass the first cut, allowing the limb to lock into itself. (See diagram below.)



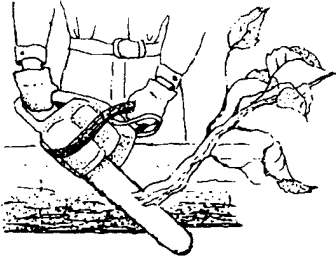
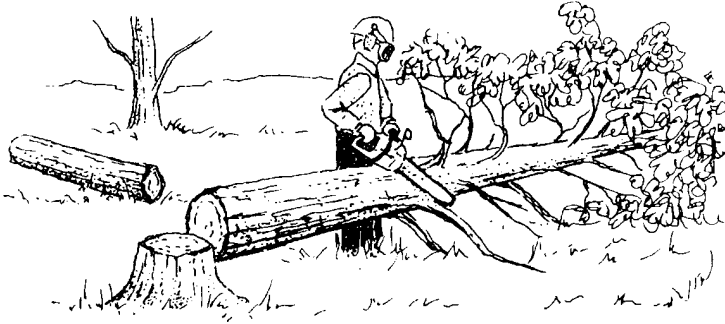
TECHNIQUE FOR SAFELY CUTTING SPRINGPOLES



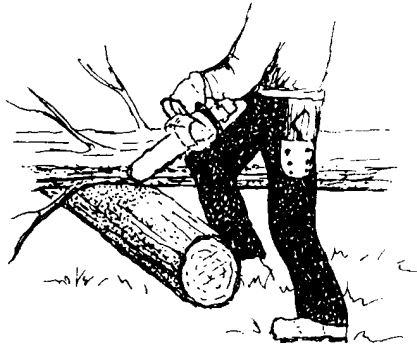
The safest way to release a springpole is to shave a sufficient amount of wood from the underside of the springpole to allow the wood fiber on the top side to release slowly.

To decide optimum point of springpole release, determine a straight vertical line from the stump to where it meets a straight horizontal line from the highest point of bend, and come down at a 45E angle from where the two lines intersect.

**WORK IN THE MOST
COMFORTABLE POSITION POSSIBLE**



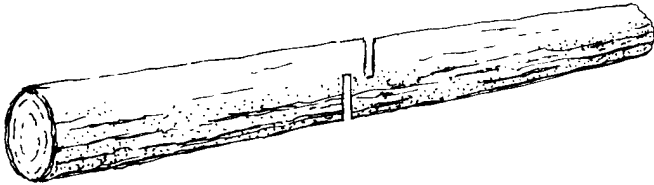
Maintain a firm stance close
And hold the saw close to
your body.



When possible, let the saw ride the trunk. Do not move your feet when the running saw is on your side of the trunk. Use the chain brake when moving over the tree or log.

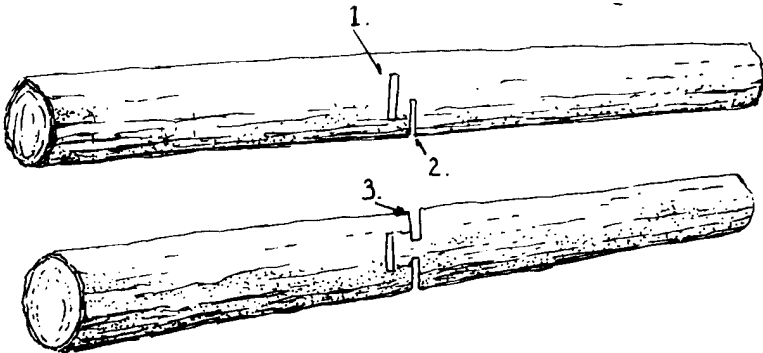
ADDITIONAL TECHNIQUES FOR LIMBING AND TOPPING

TOP LOCK TECHNIQUE



A top lock will prevent the top of the tree from kicking up and hitting the logger. The first cut is made on the compression side of the tree; the second cut is made on the tension side of the tree. The first cut is always made closest to the tree top; the second cut is made closer to the butt. Both cuts must bypass each other (see diagram).

TONGUE AND GROOVE TECHNIQUE



On steep terrain, prevent the tree from rolling by using a tongue and groove technique. First, bore through the center of the tree. Make the second cut on the compression side of the tree slightly bypassing the bore cut. The third cut is made on the opposite side of the tree in line with the second cut and slightly bypassing the first cut. This technique will prevent the tree from rolling and will separate when skidded.

BUCKING AT THE STUMP

1. Observe danger zones before bucking. Resolve potential problems such as spring poles, compression and tension stress points, terrain, potential direction of roll of log, and hanging limbs and tops. Establish an escape route. Use saws and related tools safely and efficiently.
2. Measure and mark logs to an appropriate length while considering ease of handling and further processing according to production requirement.
3. Before cutting logs or sticks consider the tree's stress points to properly place your feet and body. Use the correct saw handling methods to buck safely and efficiently according to your production requirements.

BUCKING AT THE LANDING

1. Observe danger zones before bucking. Resolve potential problems such as stress points, slippery footing, foreign objects in the pile (rocks/dirt) and in the log (nails, wire fencing, etc.), potential direction of log roll, and the possibility for a chain saw kickback.
2. Measure and mark log lengths after considering quality and production requirements. Establish an escape route.
3. Before cutting logs consider log pile compression and tension stress points to properly place feet and body. Cut logs using proper footing and body techniques as dictated by log pile compression and tension stress points, and by using saw handling methods for safe and efficient log production. A wedge will keep the cut open to avoid saw pinching.

SAFETY INSTRUCTIONS FOR BUCKING

1. Plan your cuts before starting the saw.
2. Work from the butt to the top of the tree. Work on the ground; never walk on a tree.
3. Avoid using the extreme tip of the saw for bucking to avoid kickback.
4. Only start the undercut first when the log is supported on one end. When the log is supported on two ends, you should begin with the top cut.
5. On large logs, hold the saw head against your thigh to avoid losing control if it kicks back.
6. Use a wedge to prevent binding when bucking logs.
7. Watch out for binding of the saw and possible kickback.
8. Keep the saw out of dirt and rocks.
9. Work on the uphill side if possible. If a tree is in a dangerous position, have it moved.
10. Stand with your legs at shoulder width and braced to maintain secure footing and balance. Keep as secure a footing as possible. Avoid an off-balance position where you can lose control of your saw. Bend your knees.
11. Never leave a log partially cut.
12. Make sure the chain is not turning while walking to the next cut. Keep your finger off the throttle when walking between cuts. Use the chain brake or shut the saw off when moving 50 feet or more, or when shorter distances require it.
13. Keep a minimum of two tree lengths away from fellers, and a safe distance from all other operations.
14. Keep the saw chain sharp, depth gauges correct, and the chain properly tensioned.
15. Let the saw cut through the log--don't force it.

SKIDDER OPERATIONS

1. Keep a safe distance between ground workers and other equipment in danger zones.
2. Groom the site constantly by using empty skidding equipment to push down widow-makers, spears, hang-ups, spring poles and blowdowns, and to break trails to facilitate safe, efficient skidding.
3. **Remove Spears Immediately!**
4. Position the machine at felled trees to winch straight in for safe, efficient transport.
5. When preparing to hook a skid, set the brake, secure the blade on the skidder, release the winch, and pull the mainline and chokers. You may use other related methods to prevent personal injury while efficiently and safely winching logs.
6. Use the three-point technique (one hand and two feet or two hands and one foot) to dismount the machine.
7. Use chokers as close to the butt of the tree or log as is practical for efficient production and to prevent damage and personal injury.
8. Use safe and correct methods to move the loaded skidder to the landing. Observe the correct speed for the terrain. Minimize damage to residual stands and potential dangers to yourself and others.
9. Release wood at the landing at the proper time and predetermined position to promote safe and efficient unloading.
10. Use safe and correct wood piling methods at the landing to promote efficient processing.

SAFETY INSTRUCTIONS FOR CHOKER SETTING

1. Direct your skidder operator with established signals when moving or stopping the machine.
2. Always wear gloves when setting chokers. Watch for frayed cable.
3. If you are setting your own chokers, make sure your brakes are on and the blade is down before leaving your machine.
4. Always operate the skidder's or tractor's winch from the driver's seat, never from the ground.
5. Always set chokers from the butt end unless there is a reason to skid the top first. Never set a choker in the middle of a log.
6. If the release chokers are hung up in the skid, let the skidder pull them loose. Stay clear in case they snap.
7. Stay clear of cables under tension.
8. Visually inspect cable and chokers daily for broken strands or cuts.
9. Stay clear of logs that might roll and watch out for unexpected cable or chain movement.
10. Stay behind and to the side of moving loads; never ride it.
11. Watch out for your hands and fingers when releasing chokers; they could get pinched if the logs should roll.

**SAFETY INSTRUCTIONS FOR RUBBER-TIRED
SKIDDERS OR PREHAULERS**

GENERAL SKIDDING

1. Wear a hard hat, safety boots, gloves, and eye and ear protection.
2. Only trained and authorized personnel should operate skidders.
3. Keep a first aid kit, fire extinguisher, and operator manual on the skidder.
4. Keep hands, feet, and clothing a safe distance from moving parts.
5. Keep steps free from oil, mud, grease, and ice.
6. **Do Not Have Riders;** your skidder is a one-man vehicle.
7. Seat belts shall be installed and worn.
8. Use the three-point mounting/dismounting method - one hand and two feet, or one foot and two hands.

OPERATION OF A SKIDDER

1. Drive slowly over rough terrain or down steep grades.
2. Don't leave the skidder while it is moving.
3. Don't drag the empty main line on the ground.
4. Don't winch at severe angles.
5. Don't skid across a steep slope; always skid up or down a slope.
6. On steep-sided hills, avoid abrupt uphill turns. Back downhill, then go straight uphill.
7. If it is necessary to park on a hill, set the brake and drop the blade. Use a tree or high stump for added bracing.
8. Reduce speed when turning.
9. Drive at a safe speed.
10. Raise the skidder blade when traveling and lower the blade when dismounting the machine.
11. Observe the area before backing up.

SKIDDER OPERATION

12. Use a lower gear when descending steep hills or lower the load to help in braking. Don't use the brakes--you may lose control.
13. Slow down and keep track of your load and other workers when approaching or turning on the landing.
14. Before traveling, winch your load up close to the skidder with butts off the ground to prevent hang-ups and rollovers.
15. If logs bind against stump or rock, reposition machine or unhook. Don't go in and try to cut stump **or** don't keep pulling, especially if others are in the area.

**Operators Shall Not Exceed Manufacturer's
Recommendations In The Operation Of Skidders!**

PILING/DECKING OF WOOD PRODUCTS

- ✓ Observe danger zones by keeping a safe distance between you, others, and adjacent piles.

- ✓ Initially groom the site to level the piling area. Remove widow-makers, hang-ups, spring poles, and blowdowns from the piling area. Groom the site during piling to keep the area clear of brush and debris.




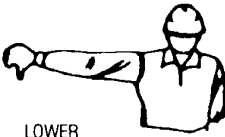
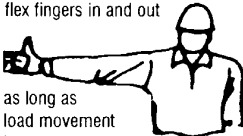
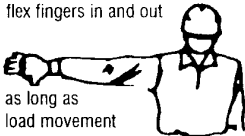
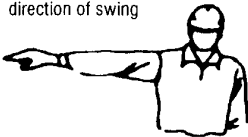


- ✓ Position piles to allow safe access of machinery. Keep the pile level and uniform to eliminate protrusions from the pile face. Ensure that decks or piles have products placed in a position that minimizes rolling and shifting, or causing decks/piles to break down.

- ✓ Position machinery to allow safe piling. Keep the pile height within operating capabilities of piling and loading equipment. Ensure that decks or piles have wood placed in a position to minimize rolling, shifting, or pile break downs.

SAFETY INSTRUCTIONS FOR KNUCKLE-BOOM LOADERS

1. Inspect the machine and clear the work area of personnel before starting.
2. Your loader is designed for lifting and loading; don't allow it to be used for anything else.
3. If equipped with stabilizers, lower them on a firm footing before doing any work with the loader.
4. Observe the work area before starting work and while loading; there may be people or objects in your work area. All truck drivers shall be a safe distance in front of and off to one side of the loading operations, and in view of the operator at all times. Hard hats are required by all operators.
5. Never let anyone get under your boom or load.
6. When working near power lines, keep a clearance of 10 feet if the voltage is 50 Kv or below. For each one Kv over 50 Kv, add an additional four inches. If the operator cannot maintain the required clearance by visual means, a person must be designated to observe and give timely warning if violation of the clearances might occur.
7. Before dismounting, lower the boom onto the boom rest or the ground.
8. Before traveling, lower and secure the boom, raise the stabilizers, disengage the pump, and secure any payload.
9. Know all the clearance dimensions for your forwarder. Check them against clearance requirements along your route of transport.
10. Be aware of blind spots from the operator's seat.

HAND SIGNALS FOR BOOM EQUIPMENT OPERATION

 <p style="text-align: center;">RAISE LOAD SLOWLY</p>	 <p style="text-align: center;">LOWER LOAD SLOWLY</p>	 <p style="text-align: center;">RAISE BOOM</p>
 <p style="text-align: center;">LOWER BOOM</p>	<p>RAISE BOOM AND LOWER LOAD Extend thumb upward and flex fingers in and out</p>  <p>as long as load movement is desired.</p>	<p>LOWER BOOM AND RAISE LOAD Extend thumb downward and flex fingers in and out</p>  <p>as long as load movement is desired.</p>
<p>SWING - Extend arm with forefinger indicating direction of swing</p> 	<p>STOP - Extend forearm and hand in horizontal position and make slicing motion.</p> 	<p>EMERGENCY STOP</p> 

POWER LINE CLEARANCES

Avoid all live overhead electrical distribution or transmission lines until the line has been visibly grounded and the owner of the utility indicates the area is safe. When a line cannot be de-energized, check your state's regulations and recommendations for safe clearance.

EQUIPMENT MAINTENANCE

All too often, machinery reaches a state of disrepair. This is not only dangerous to the operator, but also is a financial loss to the owner. This loss can be avoided by daily care, checks on the equipment, and replacing parts before injury or loss occurs. Some items, however small, can cause disabling injuries and loss time. Many hazards are created by ignoring seemingly innocent situations such as control levers without knobs.

All heavy equipment has safety features to protect the operator; do not take them for granted. Check all hydraulic systems daily for leaks that might cause a slow blade, poor steering, or poor braking action. Check all screens daily for disrepair; they protect you from branches, logs, lying debris, and cable whip. Make sure all windows are clean. A few moments of your time spent in a safety check for defects can ensure you and your employer a profitable and accident-free working day.

MACHINERY MAINTENANCE CHECKS

1. Visual - All fluid levels; check for leaks.
2. Visual - Loose nuts, bolts, cracks, hoses, pins, and damage.
3. Visual - Tires for pressure, damage, and lug bolt tightness.
4. Visual - All cable rigging or booms for damage.
5. Visual - Equipment free of debris.
6. Visual - Fire extinguisher and first aid kit.
7. Visual - Check for vandalism.
8. Check all gauges to be sure they are working properly.
9. Be sure all steps and platforms are free of oil and debris.

MAINTAINING THE SKIDDER

1. Conduct a daily circle check before operating skidding equipment. These checks should include: tires/tracks, engine, hydraulics, and winch and cable rigging for frays and condition. Also check related equipment for fluid levels, leaks, loose wheel nuts, bolts, and cracks and damage. These checks spot present or potential damage that jeopardize safe and efficient equipment operation.
2. Follow manufacturer's procedures for starting equipment to reduce maintenance and optimize safe operation.
3. Perform operational checks while seated in the operator's position. With the engine running and maximum visibility, check gauges and move controls manually to ensure all parts of the skidding equipment are working according to the manufacturer's specifications.
4. Before moving equipment conduct a visual inspection of the area to ensure that no one is in the operator's path.
5. Ensure personal safety by lowering and deactivating powered equipment such as buckets, blades, grapples, clams, and forks. Set hand brakes using correct procedures when leaving skidding equipment unattended.
6. Perform shutdown procedures according to manufacturer's specifications. Immobilizing unattended skidding equipment by lowering the blade will prevent accidental movement. Turn off master switch to avoid electrical shorting.
7. Maintain equipment by lubricating according to manufacturer's specifications. Clear all debris from the engine, manifold, brake, winch, radiator, and other areas of equipment to prevent fire and spot problems or equipment malfunctions.
8. Always keep proper records; fill out daily reports.

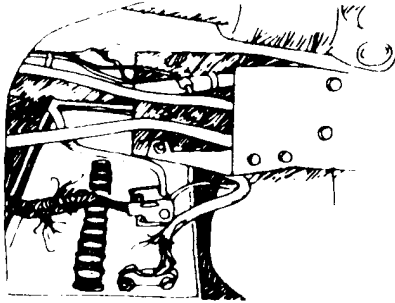
MAINTAINING PILING EQUIPMENT

1. Conduct a daily circle check before operating piling equipment. Check tires/tracks, engine, and hydraulics. Also inspect related equipment for fluid levels, leaks, loose wheel nuts, bolts, cracks, and damage. This will help spot present or potential damage before skidding operations begin. It also will optimize safe and efficient operation of equipment.
2. Start piling equipment following manufacturer's procedures to reduce maintenance and optimize safe, smooth operation.
3. Perform operational checks while seated in the operator's position. With the engine running and maximum visibility, check gauges and move controls manually to ensure all parts of the piling equipment are working according to the manufacturer's specifications.
4. Before moving equipment conduct a visual inspection of the area to ensure that no one is in the operator's path.
5. Lower and deactivate powered equipment such as clams, grapples, and forks. When leaving the equipment unattended, set hand brakes to ensure personal safety.
6. Perform shutdown procedures according to manufacturer's specifications. Immobilize unattended piling equipment by lowering grapples, clams, or forks to secure against accidental movement. Turn off the master switch to prevent electrical shorting.
7. Help maintain piling equipment by lubricating according to manufacturer's specifications. Clear all debris from piling equipment to prevent jamming and to spot developing problems or equipment malfunctions.
8. Always keep proper records; fill out daily reports.

CAUSES OF FIRE

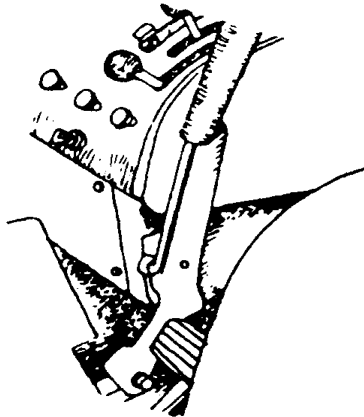
ELECTRICAL

Surveys have shown that one-third of the fires investigated started because of short circuits; damaged wiring is often the cause. Wiring and battery cables are subject to unusual wear. Wiring insulation can become abraded or torn, causing short circuits. This condition, combined with accumulations of oil and fuel-soaked debris, can cause a fire.



BRAKES

Another cause of fire is overheated brakes. Skidders are equipped with a parking or auxiliary brake which can be used to hold the skidder stationary. If the operator travels with the brake engaged, it will overheat. If not detected in time, this can cause a fire.



ENGINE AREA

Another cause of fire is flammable material coming in contact with hot engine parts. Housekeeping is the key to prevention in this type of fire. Newly purchased woods equipment is relatively safe from fire, but when working in the forest, it's impossible to prevent small particles of dry leaves, needles, branches, and twigs from building up in tight corners of the machine. All debris must be removed daily.



Debris, fuel, and oil are most likely to accumulate in the lower portions of the front frame assembly and transmission compartment.

FIRE PREVENTION GUIDELINES

- ✓ Keep the engine compartment clean
- ✓ Stop leaks and inspect the electrical system
- ✓ Stop the engine while fueling, and **No Smoking**
- ✓ Maintain a charged fire extinguisher
- ✓ Remove oil, twigs, and debris daily

FIRE EXTINGUISHERS

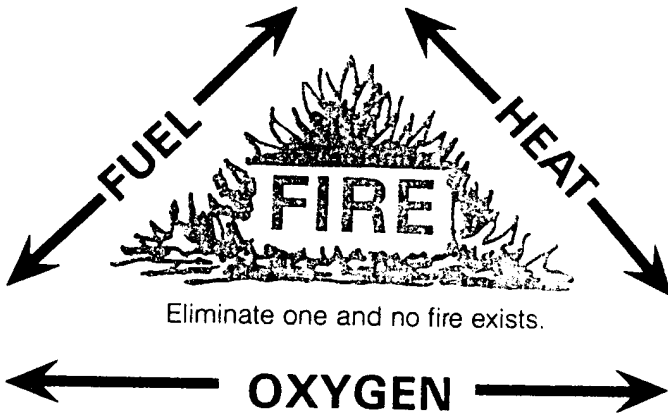
Fire extinguishers should be provided on each job site and on each piece of mobile equipment. They also should be the proper type and size for the situation.

Fuel should be stored in an approved container and kept in a safe place.

FUEL STORAGE

1. Keep only what's necessary. Large amounts may require a storage permit...check with the Fire Department.
2. Store outside if possible, or in a well-ventilated area free of ignition sources (no smoking).
3. Store in approved safety cans.
4. Post a "NO SMOKING" sign.

*The Secret to fire control is the three steps that make a fire.
Skip A Step And Stop A Fire!*



FELLER-BUNCHER SAFETY

1. Check all hydraulic lines and fittings, the hydraulic fluid level, and the motor oil level, before operating.
2. Check for vandalism before operating.
3. Check all pins and the carrier's lift arm linkage before operating.
4. Never start the carrier until everyone is completely clear of the shear.
5. Do not make any adjustments or repairs to the shear while the carrier is running or the operator is in the carrier's cab.
6. Never leave the shear unattended while the carrier is running.
7. Never leave a tree in the shear unattended.
8. Never elevate the shear to work on it unless it is supported.
9. Never elevate an unattended shear.
10. Do not attempt to shear trees larger than the shear's rated capacity.
11. Do not allow anyone within two tree lengths while the shear is in operation.
12. Do not use the shear for a "dozer" blade.
13. When working on an incline, do not work around the slope. Work uphill and deadhead downhill; the machine is more stable this way. As a general rule, a 35:1 slope is the recommended maximum for safe operations.
14. After shearing the tree, carry it low. Carrying a tree high can tip the machine and cause severe damage to the boom or loader arms.
15. Make gradual motions with the machine while holding a tree. Quick moves may cause tops to break off and fall on the cab.

16. Don't pile trees in bundles larger than skidders can handle.
17. Only trained and authorized personnel should operate equipment.
18. Keep the manufacturer's operator's manual with the equipment at all times.
19. Do not exceed the manufacturer's recommendations.



Carrying trees up or down a slope calls for special care. When carrying trees downhill, tilt the shear head back so that the tree is leaning back over the machine. When carrying trees uphill, tilt the shear head out so that the tree leans away from the machine.



FOR MORE INFORMATION

For more information on logging safety, contact:

NH Timber Harvesting Council	603-224-9699
American Pulpwood Association	207-622-3705
Occupational Safety & Health Assoc.	603-225-1629
University of New Hampshire Cooperative Extension	603-862-1028
University of New Hampshire - Thompson School of Applied Sciences	603-862-1103

Logging equipment manufacturers also can supply your company with information about logging safety, machinery maintenance, and equipment operation.

GLOSSARY

BACKCUT: The final cut in felling a tree. It is made on the side opposite the notch and direction of fall.

BALLISTIC NYLON: A fabric of high tensile properties designed to provide protection from lacerations.

BARBER CHAIR: A tree which splits up from the back cut, instead of breaking to the undercut.

BIND OR BOUND: The compression created by a cut in a tree or log due to uneven terrain or contact pressure from other trees or logs.

BINDER: A chain, nylon strap, or wire rope used to bind a load of logs.

BORE CUT: A technique used to establish a hinge.

BORING: Beginning a cut using the attack section of the tip of the bar allowing the chain to cut through a log or tree.

BUCK: To saw felled trees into shorter lengths.

BUDDY SYSTEM: The procedure in which two workers are always within sight and/or sound of each other.

CABLE: A woven wire rope. In logging, a wire rope is generally termed a "line."

CALKED BOOTS: Boots containing steel calks or spikes in the heel and soles.

CHAIN BRAKE: A safety device which stops the saw chain.

CHAIN SAW: A saw powered by an engine or motor in which the cutting elements are on a circular chain.

CHOKER: A short length of wire rope used to attach logs to a main line. It is provided with a sliding hook and a ferrule at either or both ends.

COLD DECK: A number of logs piled or decked for storage or for handling purposes. It is known as a "**Hot Deck**" when logs are taken from it before the deck is completed.

CUTTER (Feller, Bucker): One who fells, bucks, or limbs trees.

DANGER TREE: A standing live or dead tree, including snags, with evidence of deterioration or physical damage to the root system, trunk, or stem. The degree and direction of lean is also an important factor when determining if a tree is dangerous.

DIRECTIONAL FELLING: A felling technique to control the direction of fall of a tree.

ESCAPE ROUTE: A preplanned and brushed out escape route used by fellers to make their way into the clear when the back-cut is completed.

FALLER: A worker who fells trees for logging purposes. Usually he/she also is a buckler.

FELL (cut): Process of severing a tree from the stump so that it drops to the ground.

FELLERS: Workers who cut down trees.

FOPS: Falling Object Protective Structure.

GUARD: Any protective device around a machine or danger zone.

HAZARD: A condition in which risk is involved.

HINGE: The wood which controls the tree as it falls to the ground.

GLOSSARY

HOLDING WOOD: The appropriate amount of wood left at the back of the tree to hold the tree stable until ready for release.

HOT DECK: A landing where logs are constantly being moved.

KERF: The width of any saw cut.

KICKBACK: Strong thrust of the saw back toward the cutter, generally resulting from improper use of the saw. Kickback also refers to a tree jumping back over the stump toward the cutter.

KNUCKLEBOOM: A hydraulic loader.

LANDING: A term used to indicate a place where logs are hauled, piled, stored, or dumped.

LIMB: To remove the limbs from a felled tree.

LODGED TREE: Tree that has not fallen to the ground after being partially or wholly separated from the stump or otherwise dislodged from its natural position.

LOG: Tree segment suitable for subsequent processing into lumber, pulpwood, or other wood products.

LOGGER: Anyone engaged in preparing trees and transporting them to the sawmill. (Clerks, cooks, and other persons involved in a logging operation, but not actually engaged in handling the trees, are **not** considered loggers.)

LOGGING: All operations relating to the felling of trees, cutting felled trees into suitable lengths, yarding, limbing, debarking, grading, loading, hauling, unloading, and storing in decks until transformed from timber to wood products.

LOGGING MACHINE: A machine used or intended for use to yard, move or handle logs, trees, chunks, earthen material, and related material or equipment.

NOTCH: A wedge-shaped cutout which creates the opening for the tree to fall into. It also controls direction of fall.

PPE (Personal Protective Equipment): The specific OSHA-accepted items of protective clothing worn by loggers.

PULPWOOD: Wood cut or prepared for use by a pulp mill.

ROOT WAD: Mass of roots and dirt which projects above the ground level after a tree has been blown or pushed over.

ROPS: Rollover Protective System or Structure.

SAW DOGS: The metal plate containing three to five points in front of the chain saw housing, protruding parallel with the bar. They act as a pivot point for the saw during cutting.

SAW LOG: The sections of a tree of suitable character and length for handling in a sawmill and for use as lumber.

SELECTIVE LOGGING: *Choosing* trees in a certain area for logging purposes.

SET BACK: Occurs when a tree settles back opposite to the intended direction of a fall. This creates a hazardous situation when the logger loses control of a tree.

SKID: To drag logs or haul trees from the stump to a landing.

SKIDDER: A track unit or rubber-tired machine which transports logs to a designated landing.

SNAG: A dead standing tree. Also, a broken-off tree or branch of a tree.

SPRINGPOLE: Tree or branch that is under tension.

3- (THREE) POINT TECHNIQUE: Using two hands and one foot, or two feet and one hand when mounting or dismounting a piece.

Timber Harvesting Options for Woodland Owners

(Merge protected. Find at: <http://extension.oregonstate.edu/catalog/pdf/ec/ec1582.pdf>)

Timber Harvesting Options for Woodland Owners (R Parker & S Bowers, August 2006, The Woodland Workbook, Oregon State University Extension Service)

Felling and Bucking Techniques for Woodland Owners

(Merge protected. Find at: http://www.survivalprimer.com/Homestead/Logging_Felling_&Bucking.pdf)

Felling and Bucking Techniques for Woodland Owners (J Garland & D Jackson, January 1997, The Woodland Workbook, Oregon State University Extension Service)

USING ORGANIC AMENDMENTS

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AUTHORS: Cheryl Buckwalter, Organic Farming Education Program Intern,
Cindy Fake, Horticulture and Small Farms Advisor, Placer and Nevada Counties

Organic and sustainable growers use amendments such as manures, animal and plant derived meals, and mined minerals to satisfy plant nutrient needs. These amendments serve as fertilizers, but many also have beneficial effects on the soil. They may contribute organic matter and microbial biomass, as in the case of manures. They may also positively affect soil properties, for example, in sodic clay soils, gypsum causes clay particles to flocculate, improving infiltration.

Most nutrients in organic amendments are not in a soluble form, but are released slowly into the soil. This reduces the risk of leaching and nutrient loss, and thus, the potential for pollution of water resources. This is particularly important for nitrogen-rich materials.

Organic amendments are generally not as easy to use as synthetic fertilizers for a number of reasons. They are less concentrated and concentration may vary greatly from product to product, and from season to season for the same product.

Manures are particularly subject to variability, depending upon the length of time between

production and utilization, as well as the method of application. Nitrogen losses from volatilization and from leaching can be very high in unmanaged manure piles.

There are no uniform labeling standards for organic materials. Many organic amendments are wet materials, and the nutrient analysis given on the package or in charts is by **dry** weight. Manures and meals may be wet, and can contain up to 75% water. Organic amendments are also generally more expensive per pound of nutrient, compared to synthetic materials. However, ancillary benefits are not calculated into the cost.

While many use organic amendments, few growers actually calculate how much they need of each amendment to supply to nutrient needs of the particular crop they are producing. This publication is intended to help determine which materials might be best for your particular crop needs and how to calculate the amounts you need.

Calculating How Much to Use

Calculations for organic amendments can be difficult because materials may be wet, nutrient components may differ

from season to season and from brand to brand. Once you have calculated the amount needed, those calculations may be used as guidelines for future years and you may not need to calculate each time.

You should, however, be keeping track of your plant health and nutritional status. For perennial crops, a regular program of plant tissue sampling will help you to apply the correct amendments to satisfy plant needs. For annual crops, soil testing may be more helpful, especially if you grow a diversity of crops and rotate them from field to field. Tissue testing may also be done, but your crop may be half way through its life cycle before you know that it is deficient in a particular nutrient, if it is not showing obvious deficiency symptoms.

While calculations may be somewhat tedious and confusing, many users of organic amendments overapply nutrients. This can cause a number of problems, as well as being expensive for the grower. Over-application of high nitrogen amendments allows nitrogen to leach through the soil or move into waterways with storm runoff.



COOPERATIVE EXTENSION, UNIVERSITY OF CALIFORNIA

Placer County

WEB SITE: ceplacervevada.ucdavis.edu

Nevada County



11477 E Avenue (Bldg 306, DeWitt Center)
Auburn, California 95603
(530) 889-7385
FAX (530) 889-7397
E-Mail: ceplacer@ucdavis.edu

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255 So Auburn (Veterans Memorial Bldg)
Grass Valley, California 95945
(530) 273-4563
FAX (530) 273-4769
E-Mail: cenevada@ucdavis.edu

Excess applications may also cause unwanted chemical changes in the soil. For example, a soil which was acidic when cropping began, may become alkaline because of repeated applications of lime based on the original soil analysis.

Continued application of nutrients in amounts greater than that needed by the plant, can cause toxicities, which are detrimental to crop growth. A good example is

boron. The range between boron deficiency and excess is very narrow, and excess B is toxic to plants. Another nutrient that seems to often be applied in excess on organic cropping systems in the foothills is phosphorus. Many foothill soils are initially low in available phosphorus, and most amendments supply slow-release P. However, continued application without soil or plant tissue testing

can lead to excess P in the soil.

Careful calculation of nutrient needs supplied by organic amendments will save money, reduce leaching and toxicity problems, and prevent unwanted changes in soil properties.



ORGANIC AMENDMENTS & APPROXIMATE ANALYSIS (dry weight basis)

Material	Nitrogen (N)	Phosphorus (P ₂ O ₅)	Potassium (K ₂ O)	Calcium (Ca)	Other	Relative Availability	References
Percent by Weight							
Bat guano (R) (decomposed/dry)	2-10.0%	2-8.0%	0.0-2.0%			Medium	12,13
Blood (dried)	10-13.0%	1-2.0%	0.5-2.5%			Medium-Rapid	1, 5, 9,10, 11,12,15, 26, 36
Bone meal (steamed)	0.5-4.0%	11-34.0%	0.0-0.2%	22.0%		Slow-Medium	5, 9, 10, 11,12,13, 26
Calcium carbonate (dry) (oyster shell, calcitic lime [CaCO ₃])				36-50.0%		Slow-Medium	2, 6, 41, 44
Chicken manure (dry) ^M	1.0-4.5%	.80-6.0%	.39-2.4%			Medium-Rapid	2, 5, 8,10, 11,12, 36
Compost	1-8.0%	0.5-1.0%	1-2.0%			Slow	12, 26
Cow - dairy manure (dry) ^M	0.6-2.10%	0.3-1.1%	0.6-3.6%	1.36%	.36 Mg	Medium	7, 11,12, 36
Cow - steer manure (dry) ^M	1-2.5%	0.5-1.6%	1.9-3.6%			Medium	9, 11,12, 36
Dolomitic limestone (CaCO ₃ - MgCO ₃ dolomite)	0.0%	0.0%	0.0%	24-30.0	6-14.0 Mg	Slow	26, 44
Feather meal	7-15.0%				.8 Mg	Slow	2, 9, 12, 13, 15, 45

ORGANIC AMENDMENTS & APPROXIMATE ANALYSIS (dry weight basis)							
Material	Nitrogen (N)	Phosphorus (P ₂ O ₅)	Potassium (K ₂ O)	Calcium (Ca)	Other	Relative Availability ⁹	References
Percent by Weight							
Fish emulsion	3-6.0%	1-2.0%	1-2.0%			Medium-Rapid	5,11, 26
Fish meal	10-11.0%	2-6.0%	0-2.0%			Slow-Rapid	1, 6, 9,10, 11, 12, 13, 15, 36
Goat manure (dry) ^M	0.6-2.7%	.33-1.8%	.75-2.8%			Medium	11,12
Grape Pomace	0.9-3.0%	0.0-0.5%	0.0-2.0%			Slow	5, 12, 38
Greensand (glauconite, mined)	0.0%	0.0-2.0%	3-9.0%			Very Slow	12,13, 26, 44
Gypsum (mined) (calcium sulfate, CaSO ₄ · 2H ₂ O)				18.25-25.2%	15-23.2% S	Slow-Rapid (depends on particle size)	3, 6, 38, 40, 42, 44, 49
Hoof & horn meal	10-14.0%	1-2.0%	0.0-1.2%		.3 Mg	Slow-Fairly Rapid	5, 12, 36, 45
Horse manure ^M	0.7-3.0%	0.3-2.0%	0.5-3.0%			Medium-Slow	11,12, 24, 44
Kelp (liquid)	0.2%	1.0%	1.0%			Rapid	13
Kelp meal (dry)	0.7-1.2%	0.0-0.5%	1.0-5.0%			Slow	1, 5,12, 44
Potassium sulfate (K ₂ SO ₄ , sulfate of potash)			50-52.0%		16-18.0% S	Medium-Rapid	1,13, 38, 44, 47
Rabbit manure ^M	2.0-2.20%	.87-1.3%	1-2.30%	1.26%		Medium	7,11
Rock phosphate (soft)	0.00%	20-35%	0.00%	19.0%	2.7% Fe 21.0% Si	Slow, 1-2.0% immediately available	1, 6, 10, 13, 26, 44
Sheep manure ^M	2-6.0%	1-3.0%	2-2.50%			Medium	11, 12, 44
Soybean meal	6-7.0%	1-2.0%	1.5-2.0%			Slow-Medium	26, 36

ORGANIC AMENDMENTS & APPROXIMATE ANALYSIS (dry weight basis)							
Material	Nitrogen (N)	Phosphorus (P ₂ O ₅)	Potassium (K ₂ O)	Calcium (Ca)	Other	Relative Availability ⁹	References
Percent by Weight							
Sulfate of potash magnesium (potassium magnesium sulfate)			21.0%		11.0% Mg 18-23.0% S	Medium-Rapid	1, 12, 13, 26, 38, 44, 47
Wood ash (R)	0.00%	1-3.0%	3-7.0%			Rapid	1, 10, 12, 26, 36
Zinc sulfate (R)					22-36.0% Zn 17.5% S	Rapid	13, 44

Symbol Key:

M-Manures, refer to National Organic Program (NOP) rules regarding use of manures

R-Regulated, specified as a Regulated material on the Organic Materials Review Institute's (OMRI) Materials List⁵¹

Mg-Magnesium; S-Sulfur; Zn-Zinc.

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Certified Organic Growers should refer to the OMRI List and the USDA National Organic Program

Calculating Organic Amendment Needs Based on Soil Analysis						
	Nitrogen (N)	Phosphorus (P ₂ O ₅)	Potassium (K ₂ O)	Lime	Sulfur (S)	Boron (B)
Soil Analysis Recommendation	100 lbs./acre	40 lbs./acre	120 lbs./acre	2000 lbs./acre	30 lbs./acre	1 lb./acre
1. Phosphorus - Begin with phosphorus because it is the smallest recommended amount. To calculate how much is needed to supply 40 lbs. of phosphorus, divide recommended amount by percent (decimal) in amendment.						
Source & Nutrient Content:						
	<i>Bone Meal</i>	3% N	20% P ₂ O ₅	0.2% K ₂ O ₅		
	Recommended Rate (lbs./acre) of Phosphorus		Percent Phosphorus in Amendment		lbs./acre of Bone Meal to Apply	
	40 lbs.	÷	.20 (20%)	=	200 lbs./acre	
2. Before figuring out how much of the next amendment is needed, first determine how much of the other nutrients (nitrogen and phosphorus) are being supplied with the bone meal. To do this, multiply number of pounds of bone meal applied to satisfy P recommendation by the percent nitrogen (decimal) supplied by bone meal.						
	lbs. applied to satisfy P Requirement		Percent Nitrogen in Amendment		Amount of Nitrogen in Bone Meal	
	200 lb./acre	x	.03 (3%)	=	6 lbs./acre	
	lbs. applied to satisfy P Requirement		Source Nutrient Proportion (%) of Potassium		Amount of Potassium in Bone Meal	
	200 lb./acre	x	.002 (.2%)	=	.4 lbs./acre	
3. Nitrogen - To calculate the lbs. of amendment needed to satisfy the recommended nitrogen rate, subtract the number of pounds per acre of nitrogen already provided in bone meal (item 1) from the recommended amount of nitrogen.						
	Recommended Rate (lbs./acre) of Nitrogen		Amount supplied from Bone Meal		Amount of Nitrogen still needed	
	100 lbs.	-	6 lbs./acre	=	94 lbs.	
Select a source for the remaining N needed to satisfy recommendation. This example uses feather meal.						
Source & Content:						
	<i>Feather Meal</i>	15% N	0% P ₂ O ₅	0% K ₂ O		
	Remaining amount of N needed		Percent Nitrogen in Amendment		lbs./acre of Feather Meal to Apply	
	94 lbs.	÷	.15 (15%)	=	627 lbs./acre	

4. **Potassium** - Calculate number of lbs. of nutrient or amendment needed to satisfy recommended amount of potassium (K) per acre. The calculation is basically the same as in step 3., but here is a way to skip a step. First subtract the amount of potassium already supplied by bone meal, then divide that amount by the source nutrient.

Source & Content:

	<i>Potassium Sulfate (K₂SO₄)</i>	50% K ₂ O	18% S					
Recom- mended K (lbs./ acre)		Amount from Bone Meal		Recom- mended K		Percent K in amendment		lbs./acre of K ₂ SO ₄ to apply
120 lbs./ acre	-	0.4	=	120 lbs./ acre	÷	.50 (50%)	=	240 lbs./ acre

5. **Sulfur** - Before determining how much sulfur is needed, first calculate how much sulfur was provided in potassium sulfate. To do this, multiply number of pounds of potassium sulfate to be applied by the proportion (%) of sulfur in source material.

	lbs./acre K ₂ SO ₄ applied		Percent S in amendment		Amount S in Potassium Sulfate			
	240 lbs./ acre	x	.16 (18%)	=	38.4 lbs.			

Note that this is more sulfur than recommended.

6. **Boron** - To calculate how much of the source nutrient or amendment is needed to supply 1.0 lb./acre of boron, divide recommended amount by the source. In this example, borax was selected.

Source & Content:

	<i>Borax (R)</i>	11.30% Borax						
	Recom- mended Rate (lbs./ acre) of Boron		Percent B in amend- ment		Amount of Borax to Apply			
	1.0 lbs./ acre	÷	.113 (11.3%)	=	9 lbs./acre			

R - Regulated under Organic Materials Review Institute (OMRI) Standards

7. **Lime** - To calculate how much of the source nutrient or amendment is needed to supply 2,000 lbs./acre of Lime, divide recommended amount by the source. In this example, Dolomitic Limestone is the source.

Source & Content:

	<i>Dolomitic Limestone</i>	100% lime				
	Recommended Rate (lbs./acre) of Lime		Source Nutrient Proportion (%) of Dolomite			Amount of Dolomite to Apply
	2,000 lbs/acre	÷	1	=	1 (100% Lime)	2,000 lbs./acre

8. **Cost** - Next calculate the cost per acre to apply each nutrient or amendment. Beginning with the cost/package or Container column, divide that cost by the number pounds in the package to obtain the cost per pound. Multiply the cost by the number of pounds needed per acre to obtain the cost per acre per nutrient.

	Cost per Package or load		Size of Package in lb. (e.g.: 50 lb. Bag)		Cost per Pound		No. of lbs. Need to Apply / acre		Cost / Acre / Nutrient
Bone Meal	\$23.20	÷	50	=	\$0.46	x	200	=	\$92.80
Feather Meal	\$13.50	÷	50	=	\$0.27	x	627	=	\$169.29
Potassium Sulfate	\$11.20	÷	50	=	\$0.22	x	240	=	\$53.76
Borax	\$45.00	÷	50	=	\$0.90	x	9	=	\$8.10
Dolomite	\$5.99	÷	50	=	\$0.12	x	2,000	=	\$239.60
					TOTAL COST PER ACRE			=	\$563.55

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- 52) *Consolidated National List (7CFR 205.600-607), December 2001 Final Rule with Amendments.* 2003. Compiled by the Organic Materials Review Institute. Eugene, OR.

INTERNET RESOURCES ON ORGANIC FARMING

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COMPILED BY: Cindy Fake, Horticulture and Small Farms Advisor, Nevada & Placer Counties

Organic Farming & Certification

<http://www.ams.usda.gov/nop/> National Organic Program Information

http://www.cdffa.ca.gov/is/i_c/organic.html California Organic Program

<http://www.ccof.org/> California Certified Organic Farmers

<http://www.sarep.ucdavis.edu/Organic/index.htm> University of California Sustainable Agriculture Program organic farming research and information

<http://attra.ncat.org> National Sustainable Agriculture Information Service

<http://ofrf.org/index.html> Organic Farming Research Foundation Resources page

<http://anrcatalog.ucdavis.edu/pdf/7247.pdf> Organic Certification, Farm Production Planning, and Marketing

<http://www.ams.usda.gov/nop/CertifyingAgents/CertAgenthome.html> Organic certifiers

<http://www.omri.org/> Organic Materials Review Institute. fertilizers, pesticides and other allowed materials under National Organic Program rules

Composting

<http://attra.ncat.org/soils.html> Soils & Compost information

<http://www.woodsend.org/> Woods End Laboratory—compost testing and information

http://compost.css.cornell.edu/Composting_homepage.html Cornell University Composting

Covercrops

<http://www.sarep.ucdavis.edu/ccrop/> Cover Crops Resource Page

<http://attra.ncat.org/attra-pub/covercrop.html> Overview of Cover Crops and Green Manures

Organic Amendments

<http://anrcatalog.ucdavis.edu/pdf/7249.pdf> Soil Fertility Management for Organic Crops

<http://attra.ncat.org/attra-pub/PDF/soilmgmt.pdf> Sustainable Soil Management

<http://attra.ncat.org/attra-pub/PDF/manures.pdf> Manures for Organic Crop Production



COOPERATIVE EXTENSION, UNIVERSITY OF CALIFORNIA

Placer County

WEB SITE: ceplacervevada.ucdavis.edu

Nevada County



11477 E Avenue (Bldg 306, DeWitt Center)
Auburn, California 95603
(530) 889-7385
FAX (530) 889-7397
E-Mail: ceplacer@ucdavis.edu

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255 So Auburn (Veterans Memorial Bldg)
Grass Valley, California 95945
(530) 273-4563
FAX (530) 273-4769
E-Mail: cenevada@ucdavis.edu


Specific Crop Information

<http://fruitsandnuts.ucdavis.edu/> Publications, organizations, information on fruit production
<http://www.attra.org/organic.html> ATTRA organic production of fruit, vegetable, flower crops
<http://www.attra.org/attra-pub/fruitover.html> Overview of Organic Fruit Production
<http://www.attra.org/attra-pub/cutflower.html> Sustainable cut flower production
<http://www.sustainablewinegrowing.org/> California Sustainable Winegrowing Alliance
<http://vric.ucdavis.edu/selectnewtopic.organic.htm> Organic vegetable production
<http://citrusresearch.org> California Citrus Research Board

Cost/Return Studies for specific crops

<http://www.agecon.ucdavis.edu/outreach/crop/cost.htm> University of California Davis. Includes organic and foothill production studies of mandarins, mixed vegetables, grapes, apples, and stonefruit.

Pest Management

<http://www.ipm.ucdavis.edu/PMG/crops-agriculture.html> UC Statewide Integrated Pest Management Project: information on specific pests including organic management 

<http://anrcatalog.ucdavis.edu/pdf/7250.pdf> Weed Management for Organic Vegetable Crops
<http://anrcatalog.ucdavis.edu/pdf/7251.pdf> Insect Pest Management for Organic Vegetable Crops
<http://anrcatalog.ucdavis.edu/pdf/7252.pdf> Plant Disease Management for Organic Vegetable Crops
http://www.nysipm.cornell.edu/organic_guide/ Cornell University Organic Guides for specific crops (cole crops, carrots, beans, potatoes, apples, etc.) Be sure materials are allowed in California.
<http://www.nysaes.cornell.edu/pp/resourceguide/> Cornell University Guide to Organic Pest Management.

UC Publications and Information Resources

<http://anrcatalog.ucdavis.edu/> UC Division of Agriculture and Natural Resources Sustainable Agriculture Publications. ***UC ANR Publications are available in our offices.***
<http://ceplacer.ucdavis.edu/> UC Cooperative Extension, Placer/Nevada
http://extension.ucdavis.edu/unit/agriculture_and_food_science/ UC Davis Extension ag classes

Organic Farming Supplies

<http://www.organic-growers.com/supplies.htm> organic farming suppliers
<http://www.allorganiclinks.com/category/Farm+Supplies/15> organic farming suppliers
www.groworganic.com Peaceful Valley Farm Supply



n.b. Inclusion in this list does not imply endorsement, nor is criticism implied of sites not listed here.

Organic and Untreated Seed Suppliers

Company Name	Phone		Website & E-mail Add	Comments
Abundant Life Seeds	541.767.9606		www.abundantlifeseeds.com	
Baker Creek Heirloom Seeds, Missouri	417.924.8917	seeds@rareseeds.com	http://rareseeds.com/ Email: seeds@rareseeds.com	
Bountiful Gardens			www.bountifulgardens.org	
Coke Farm	831.623.2100	ccattin@cokefarm.com	ccattin@cokefarm.com	onion transplants
Dixondale Farms, Carrizo Springs, Texas	830.876.2430		http://www.dixondalefarms.com	onion transplants
Double D				seed garlic and shallots
Environmental Seed Producers	805.735.8888		www.espseeds.com	
Fedco Seeds, Waterville, Maine	207.873.7333		www.fedcoseeds.com	Organic and untreated, commercial varieties in quantity, less expensive than most
Harris Seeds	800.544.7938		www.harriseseeds.com	
Highmowing Seeds	802.472.6174		www.highmowingseeds.com	Organic only
Johnny's Selected Seeds, Maine	877.564.6697		www.johnnyseeds.com	Organic and untreated, commercial varieties in quantity, excellent customer service for questions
Lockhart Seeds, Stockton, CA	209.466.4401		http://www.lockhartseeds.com/	website under construction
Nature Hills, Omaha, NE	402.934.8116		http://www.naturehills.com/	
Peaceful Valley Farm Supply, Grass Valley	888.784.1722		www.groworganic.com	
Prather Ranch	530.941.0810	rickertjames@yahoo.com	http://www.pratherranch.com/strawberries05.php Email: rickertjames@yahoo.com	organic strawberry plants, min. order 1,000 plants, Chandler, Camarosa, Seascape, Aromas & Albion
R.H. Shumway's Seeds, Randolph, WI	800.342.9461		www.rhshumway.com	
Ronnigers, Colorado	877.204.8704	craig@ronnigers.com	Email: craig@ronnigers.com	organic and naturally grown seed potatoes
Seed Savers Exchange	563.382.5990		www.seedsavers.org	rare/hard to find
Seeds of Change	888.762.7333, 877.470.7619		www.seedschange.com	Organic only, good selection
Snow Seed company, Salinas, CA	831.758.9869		www.snowseeds.com	large quantity only
Territorial Seed Company, Cottage Grove, OR	800.626.0866, 888.657.3131	info@territorialseed.com	http://www.territorialseed.com Email: info@territorialseed.com	
Wild Garden Seed	541.929.4068		www.wildgardenseed.com	\$50 min. order

Session 2: Highland Farm Economics – Economics from the farmer’s point of view

Presented by Allen Edwards and Dan Macon

Forget about GNP, the National Debt, and the Global economy. Set aside thoughts about elasticity of demand, internal rates of return. We are talking Farm Economics, which is all about making decisions that will help financially sustain the farm.

What most folks are after in a farm business is simple -- high profits and low expenses. But how do we get there? This session won't teach you all the fine details of farm economics. But it will offer some basic concepts that will help focus your thinking. Using these concepts can help you learn how to manage your farm for financial success.

1. Farm economics – the interaction of three fundamental factors: Fixed costs, Variable costs, and Income.
 - Fixed costs
 - What are fixed costs and how do they function
 - Approaches to lowering fixed cost per unit output
 - Frugal capital improvements
 - Substituting labor for capital
 - Using unused resources -- enterprise stacking
 - Variable costs
 - What are variable costs and how do they function
 - Approaches to lowering variable costs per unit
 - On-farm inputs (including your muscle and brain power)
 - Work planning
 - Work efficiency (work planning)
 - Have the right tool
 - Do the right task
 - Handle time
 - Enterprise stacking
 - Maintenance – the hidden factor X
 - Equipment and facilities
 - Farm plan
 - Farm family
 - Income – approaches to increasing income from your farm resources
 - Direct marketing
 - Differentiating your product
 - Relationship marketing
 - Adding value
2. Applying economic tools to help make farm decisions: How analyzing fixed costs, variable costs, and income can help make farm management decisions.
 - Using the multi-enterprise spreadsheet
3. Putting it into practice -- Case studies

- Working in the woods – stacking enterprises
 - Produce firewood
 - Thin saw logs/poles for lumber and pole beam/posts
 - Enhance goat/poultry feed
 - Culture Christmas trees
 - Reduce fire hazard
- Working at the farmstead -- synergy
 - Livestock as farm workers and harvest machines
 - Greens/ vegetables
- Value added
 - Trees to finished wood products

4. Principles to follow:

- Make a living wage
- The key to economic success is efficiency; the key to efficiency is attention to details
- You are a working farmer not an investor – using money to make your work more efficient.
- Try to make a profit for every hour you work
- Try to make every task work for several enterprises, or solve several problems
- Avoid debt like the plague
- Increase your profit by selling directly to consumers

RANCHING FOR PROFIT

THE THREE SECRETS FOR INCREASING PROFIT

There are only three choices in any business: 1. We can make it profitable; 2. We can subsidize the business; or, 3. We can go out of business (bankruptcy). Whether we realize it or not, most of us choose the second option, we subsidize our businesses. I'm not speaking about government subsidies, but rather the ways in which we subsidize ourselves. Living off inherited wealth and appreciating land values, relying on off-farm income to make ends meet and working for less than it would cost to replace yourself are all ways in which we subsidize our ranches.

I'll assume that most ranchers would rather not have to subsidize their ranches and would prefer to make profit. There are only three ways to increase profit. At Ranch Management Consultants we call them the three secrets. They are:

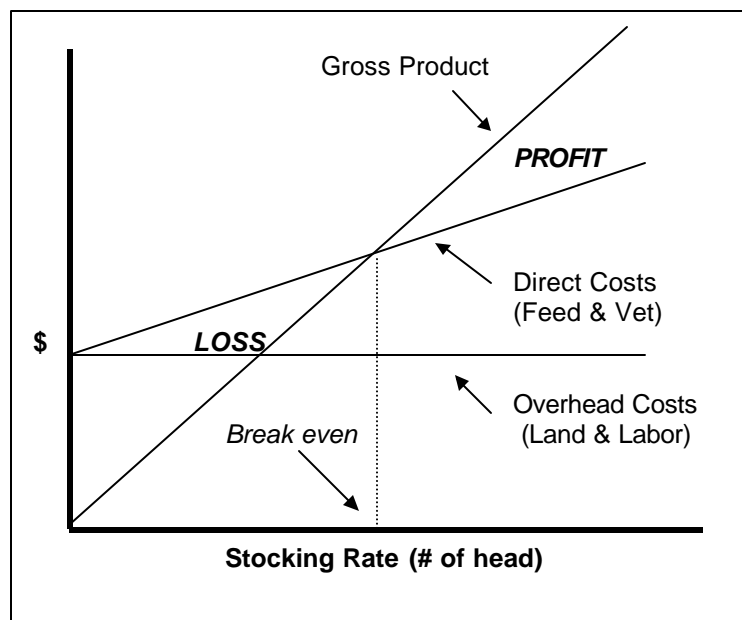
1. Reduce Overhead Costs
2. Improve Gross Margin Per Unit
3. Increase Turnover

Reducing Overhead Costs

Overhead costs are those costs that don't change much as livestock numbers change. There are two types of overheads: land and labor costs. Any costs related to land (e.g. fencing or water trough repairs, property taxes, leases, etc.) are overheads. Likewise, any costs related to labor (e.g. salaries and benefits, vehicles and equipment costs, etc.) are labor overheads. Economists sometimes call these fixed costs. But they are not fixed, they can be changed, and that is one of the three secrets for increasing profit.

Improve Gross Margin Per Unit

Gross margin is a measure of the economic efficiency of your livestock. It is calculated by subtracting the *direct costs* of production from *gross product*. Direct costs are those costs that increase or decrease as cow numbers increase or decrease. Direct costs include feed, health, freight, marketing commissions, and interest on livestock loans. Gross product refers to the gross value of production. This includes livestock sales minus purchases. It also includes changes in the value of your herd. Total gross margin is divided by the number of animals in the herd to calculate gross margin per unit. Increasing gross margin per unit (the efficiency of production) is another way to increase profit.



Increase Turnover

In ranching, “turnover” is the number of animal units carried. If gross margin is positive, increasing turnover will increase profit if it doesn’t increase land or labor costs or damage the resource base. However, there is no point in increasing the number of units if each unit makes a negative contribution toward overhead costs.

Historically, as an industry we have tried to increase profit by increasing production (increasing gross product). We have done an amazing job increasing conception rates and weaning rates. In fact, I’m told that the average beef cow in Alberta produces 20% more pounds of beef per year than she did just 20 years ago. So why aren’t we 20% more profitable? Part of the answer is obvious: the increased production resulted from, among other things, increasing direct costs (e.g. feed, health products, etc.). But there is more to the story. Those direct costs had to be administered by someone (increasing labor overheads) somewhere (increasing land overheads). On most ranches today, overheads account for 60-80% of total costs. It is the cost of building and maintaining the infrastructure we created to increase our efficiency that has depressed profit.

Imagine a chain with three economic links: overheads, gross margin per unit and turnover. If the gross margin link is weak, strengthening the overhead and turnover links won’t make the chain stronger, in fact, they may make the chain weaker by putting more stress on the weak link. In the next article in this series I’ll describe how to find the weak link for your business. That’s critical if you want to be Ranching For Profit.

David Pratt, of Ranch Management Consultants, teaches the Ranching for Profit School in Africa, Australia and North America.
Ranch Management Consultants LLC., 953 Linden Ave. Fairfield, CA 94533 USA
Tel: 707-429-2292
E-mail: pratt@ranchmanagement.com www.ranchmanagement.com

RANCHING FOR PROFIT

DIAGNOSING PROBLEMS & OPPORTUNITIES

In my previous article I showed that there are only three things a rancher can do to increase profit: 1. Decrease the overhead costs; 2. Improve the gross margin per unit; and 3. Increase the turnover (the number of units). But only one of these three things is the most important. If high overheads are the problem, increases in production efficiency are likely to increase your work load but may not significantly increase profit. If gross margin is the problem, then decreasing overheads won't have much effect and increasing turnover may actually help you go broke faster. It isn't enough to know the numbers. We must now find out what the numbers mean.

The diagram below shows the thought process we teach people at the Ranching for Profit School to diagnose the problems and opportunities in their businesses. Let's take a closer look.

We calculate profit by adding the gross margin for each enterprise and subtracting overheads. If the difference is positive the business made profit. If it is negative the business lost money.

$$\begin{array}{r} \text{Gross Margin (enterprise a)} \\ + \text{Gross Margin (enterprise b)} \\ + \text{Gross Margin (enterprise z)} \\ - \text{Overhead Costs} \\ \hline \textbf{Profit (Loss)} \end{array}$$

Profit is calculated by subtracting overhead costs from gross margin. So if profit is low it is either because gross margin is too low or overheads are too high.

Gross margin is calculated by subtracting direct costs from gross product, so if gross margin is too low, it is either because direct costs are too high or gross product is too low.

Gross product is a measure of how much we produced and how much we got paid for it, so if gross product is too low it is either because we didn't produce enough (production), or we didn't get paid enough for what we produced (price).

If we didn't get paid enough it is either because the market is too low or our marketing is not adequate.

If the gross product is low but the price is reasonable then production is too low. If production is low it is either because we didn't produce enough things (reproduction) or because the things we produced weren't big enough (gain).

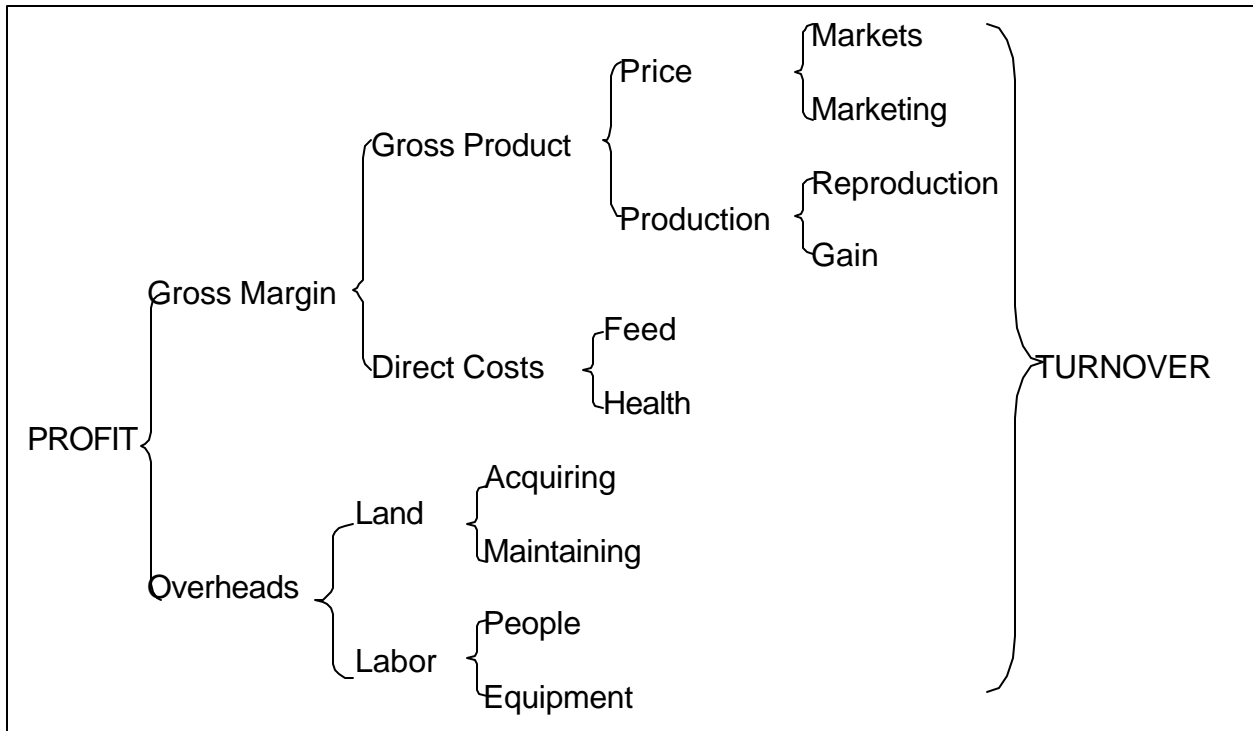
If gross margin is low, but gross product is not the problem, then the focus turns to direct costs. There are only two major direct costs: feed costs and health related costs.

If gross margin is healthy but the business still isn't profitable, the problem may lie in the overhead cost category. There are only two kinds of overheads: land costs and labor costs.

There are only two kinds of land costs: the cost of getting land (e.g. lease payments) and the cost of maintaining the land and the improvements on it.

If land costs aren't the problem, the focus turns to labor. There are two major labor costs: costs associated with people (e.g. salaries, retirement plans, health benefits, etc.) and costs related to vehicles and other equipment.

But we also know that cutting overheads and improving gross margins aren't the only ways to increase profit. Increasing turnover is the third way to increase profit. If gross margins are healthy and there's no room left to cut overheads, then turnover is probably the most promising way to increase profit.



At the Ranching for Profit School, participants review a case study of an actual ranch business in dire economic condition. When asked for solutions on the first day students come up with a shotgun array of possibilities. After using this thought process to guide them they discover the source of the problem and find that some of their original solutions would have actually made matters worse.

This procedure can help you pin point problems and opportunities in your business. And that's essential if you want to be Ranching For Profit.

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Ranch Management Consultants LLC., 953 Linden Ave. Fairfield, CA 94533 USA
Tel: 707-429-2292
E-mail: pratt@ranchmanagement.com www.ranchmanagement.com

Economics Glossary

Break Even – Gross Product – Direct Costs – Overheads = 0. This means you are only keeping your head above water. **This is not sustainable!**

Break Profit - Gross Product – Direct Costs – Overheads = Profit. You determine the amount of profit you want the business to generate. **This is sustainable!**

Capital Expenses - Capital expenses are things for which we pay money but which still have value. (A pickup purchased for \$20,000 cash is still worth \$20,000. The value has not been lost, it has simply been transferred from cash to truck. However, the moment the pickup became ours its value declined due to depreciation. The principle we paid for the pickup was not a cost to the business because we retained that value. However, depreciation, tax, license, insurance, interest, fuel, and maintenance are costs. They are overhead costs.)

Direct Costs – Expenses that vary in direct proportion to the enterprise. If one more animal or acre was added or subtracted, the cost would change. Examples would include: veterinary expenses, interest on capital invested in livestock, and fertilizer (farming).

Enterprise - An enterprise is any part of a ranch operation that could be run as a separate business. A cattle ranch might have cow-calf, stocker, finishers, and meat as enterprises. An enterprise must have direct costs. The only exception would be custom grazing which normally have little to none in direct costs.

Enterprise Analysis - Enterprise analysis is the process of examining the economic efficiency of an enterprise.

Gross Margin - The relationship between direct costs and gross product is called *gross margin*.

Gross Income – Direct Costs = Gross Margin

Gross Margin/ # Head exposed to the bull = Gross Margin per head

Gross margin measures the relative profitability of enterprises in your business.

The **gross margin per unit** (per acre or per head) is a measure of the economic efficiency of an enterprise. Gross margin/unit can be used to compare your enterprises to enterprises on other ranches.

Gross Product – The value of what you produce. This takes into account opening and closing inventories, sales, and purchases. The calculation is as follows:

Closing Inventory
+ Sales
- Purchases
- Opening Inventory
= Gross Product

Non-cash costs - noncash costs may significantly impact the net worth of their business. Below are two examples:

Depreciation

- Depreciation is the decline in the value of things we own.
- Even though it does not involve cash, depreciation must be included in the analysis.
- Depreciation on machinery is a labor related overhead.
- Depreciation on facilities is a land related overhead.
- Depreciation of cows is automatically accounted for by valuing animals conservatively in the inventory. (For example, if you bought 5 young cows worth \$750 each. The value listed in the closing inventory is \$500. That's \$200 of depreciation/head automatically accounted for in the inventory valuation.)

Opportunity costs

- Opportunity costs are the noncash costs reflecting the chance to do something else with our resources. (For example, you could choose to sell the cattle and invest the money elsewhere. The potential income on the capital formerly invested in the herd is an opportunity cost. Likewise, since you could lease the ranch to someone else for \$20/acre, you could charge the business a \$20/acre opportunity cost on the land. This is an overhead cost if you own the land.

It is necessary to include opportunity costs in an economic analysis for several reasons including:

- Opportunity costs reflect the real economic cost of not capitalizing on an alternative investment.
- Charging opportunity interest is necessary to compare enterprises within a business or between businesses. For example, Willie borrowed money from a bank to purchase the stocker cattle, but he owns the cows. He pays real interest as a variable cost in the stocker enterprise, but pays no interest on the cows. To compare the economic efficiency of these enterprises, Willie must level the playing field by charging interest on the cows.

Overhead Costs

Overhead costs are costs that occur at roughly the same level regardless of how much we produce on the ranch.

There are three basic types of overheads:

1. Land related overheads.

Land costs (rent, property taxes, etc.) are ***always*** overheads. Even if a lease is paid on an AUM (animal unit month) or per head basis, it should be considered an overhead. While it may seem to contradict the definition, if we are to diagnose problems and opportunities, like costs must be grouped with like costs.

2. Labor related overheads.

Labor costs are ***always*** overheads (except for fertility and pregnancy testing). Labor costs include salaries, payroll taxes, housing, and vehicle costs. Interest, insurance, depreciation, repairs, and fuel costs of machinery are also labor overheads. (You can do the same job with a shovel as you can with a backhoe---it will just take a tad longer.) All of the costs associated with the pickup are labor overheads.

3. Administrative overheads.

Banker Definition of Profit and loss

Profit is an increase in net worth.

Loss is a decrease in net worth.

Net worth is the difference between what you own and what you owe.

Ranching for Profit Definition of Profit

From the value you produce could you pay:

Cash Rent For Land

Full Cost of Labor

Interest On All Assets Used

All Other Production Costs

And still make a good return on your investment?

RANCHING FOR PROFIT

MANAGING CASH FLOW

There are three basic questions we need to think about when it comes to money in our businesses:

1. Is it profitable? (economics)
2. How will I pay for it? (finance)
3. What are the tax consequences?

This is the order in which we should ask the questions. If a venture isn't profitable, the financing should be irrelevant. It doesn't make any sense to finance a losing proposition. If the business is profitable, and we've created adequate cash flow, then we should take steps to minimize taxes. Too often we ask these questions in reverse order and in our efforts to minimize taxes make questionable economic or financial decisions.

Sometimes financial constraints limit economic opportunities. For example, if an investment pays big dividends in several years from now, but doesn't provide short-term cash flow we may find it hard to put food on the table now. But frequently the constraints are self-imposed and result from not recognizing the time value of money or being unwilling to manage cash flow.

Here's an example. A rancher recently told me that he needed to maintain a spring calving herd and a fall calving herd so that he had income twice a year instead of once a year. He acknowledged that it would probably be more profitable to shift to one herd, but said he needed income twice a year to make their loan payment. This isn't a problem of two paychecks versus one. The problem is ignoring the time value of money and failing to manage cash flow.

Time & Money

Which would you rather have: \$120,000 today, or \$10,000 a month for the next 12 months? Using simple interest at a rate of 10%, the \$120,000 paid today would be worth \$132,000 a year from now. The \$120,000 paid over the next 12 months in equal installments would be worth about \$125,500 at the end of the year. I'll take the money up front please.

Managing Cash Flow

Managing cash flow begins with creating a cash flow budget that projects income and expenses for the year. At the Ranching for Profit School we teach participants how to construct a cash flow including one income column

Cash Flow				
	Income	Overhead Costs	Direct Costs	Capital Expenses
JANUARY				
Budget				
Actual				
Difference				
Cumulative Difference				
FEBRUARY				
Budget				

per enterprise, several columns for overhead costs, several for direct costs, and at least one for capital expenses. We use four rows for each month. The first row is to record the budget for each income and expense item. A good time to prepare the budget is after weaning and preg-checking in the fall. The next row shows the expense for each item that was actually incurred that month. This should be completed as soon as figures are in for that month. The next row simply shows the difference between the budget and the actual expenses for that month and for the year to date.

The cash flow clearly shows periods of cash surpluses and shortages before they occur and can help you determine how to manage through these periods. It will help determine if, when and how to use short-term financing. But the cash flow is more than just a page of income and expense figures. At the *Ranching for Profit School* we refer to the cash flow as *“the minutes of the production meeting, written in dollars and cents.”* The plan communicates precisely what is planned to partners and workers. It shows when you expect sales to occur, and when you anticipate making major purchases. It will also help you determine the tax consequences of your plans well before the taxes are due.

The cash flow plan is more than just a budget. In fact, the greatest value of the cash flow is not the plan itself, but the process of completing it. The thought that goes into assessing various management alternatives is much more important than the sheet of paper (or the computer screen) that holds your projections.

The cash flow is also a monitoring tool. By updating it each month to show the actual movement of cash into and out of the business it will send up a red flag warning as soon as there is a significant deviation between the budget and actual income and expenses. Used this way, the cash flow becomes an essential tool if you are Ranching for Profit.

David Pratt, of Ranch Management Consultants, teaches the Ranching for Profit School. For more information visit www.ranchmanagement.com , or contact him at 707-429-2292 or e-mail: pratt@ranchmanagement.com .
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Elements of a Farm Business Plan

1. *Executive Summary*: a 1-2 paragraph summary of what your business is
1. *Mission Statement*: brief statement of what your business does, its purpose, values
2. *Vision Statement*: Where is your business going? Business goals? Where do you want your business to be in 5 years? 10? What your world will look like when you've accomplished your mission?
3. *Business Concept*: your product, its uniqueness, your target market, how you fit into the markets in the area
4. *Operational Characteristics & Plan*
 - Physical Resource Inventory & Plan, including a map
 - Human Resource Inventory & Plan
 - Potential crops & Production Plan
 - Timeline for farm development
 - Agencies, references, resources consulted or to consult
 - Transition Plan
 - Emergency Plan
5. *Goals and Objectives*: a realistic list of tasks, decisions to be made, actions
6. *Background Information*: summarize market research and analysis, trends in the larger ag industry.
7. *Management and Organizational Structure*: how you run your business; management, staff, legal structure, insurance.
8. *Sales & Marketing Plan*: how do you plan to market your product?
 - *Product or service marketing plan*
 - *Plan for marketing "the business"*
9. *Financial Plan*:
 - Current Financial Assessment
 - Strategic Analysis and Proposed Alternatives
 - Existing debt & repayment schedules
 - Financing needs: projections for proposed alternatives
 - Fixed assets, start-up costs
 - Risk management plan
 - Financial monitoring and control plan: cash flow forecast
 - Financial documents to include: 1) profit and loss statement 2) balance sheet including assets, liabilities and net worth 3) cash flow projections including sales projections and assumptions.
10. *Appendix*: supporting documents

Cultivation cost study

Overview

This study was completed in order to compare the total cost (capital and operating) of 5 options for weeding cultivation. These options are the principle options available to small sustainable farms. The options are as follows:

- Hand hoe – the cost here assumes a glaser 5 inch stirrup hoe
- Wheel hoe – this is assumed to be a glaser professorial model with an 8 inch stirrup hoe attachment
- Rototiller – this is assumed to be a professional grade machine.
- Tractor – this is assumed to be a 25 to 35 hp diesel machine with an implement bar and cultivation attachments
- Draft animal – this is assumed to be a medium sized horse or mule (1100 to 1300 lb) with a riding cultivator (fore-cart with cultivator setup or the equivalent).

These options were analyzed for three different scales of farming operation: 100,000 feet of 30 inch row cultivation (This would be consistent with a market vegetable operation of one to two acres); 500,000 feet of row cultivation (5 to 10 acres); and 1,000,000 of row (10 to 20 acres).

Inputs and assumptions

The following are input data and assumptions in the analysis:

- The tractor is assumed to have a residual value of \$2500. None of the other options is assumed to have residual value beyond their lifetimes. (table 1)
- The annual interest on capital investment (opportunity cost) is assumed to be 7 %. (table 1)
- All farm labor has a total cost of \$15 per hour. (table 2)
- The non-capital overhead (table 2) assumes the following:
 - the hand hoe and wheel hoe each require approximately 2 hours of maintenance per year,
 - the rototiller and tractor will require on-farm maintenance (oil change, lubrication, etc), and will require an average level of repairs by outsiders each year,
 - the draft animal will require daily care (feeding, grooming, periodic hoof care, etc) which is assumed to average 20 minutes per day. It will also require care from an outside vet which will average \$150 per year,
- The time required to cultivate with a hand hoe, wheel hoe are based on personal experience. The time required for the tractor and the animal assumes each will cultivate 2 rows at a pass, traveling approximately ½ mile per hour on average (including turns), (table 3)
- The equipment operating costs (table 5) makes the following assumptions:
 - the hand and wheel hoes will wear, and need whole or partial replacement
 - the rototiller will have operating costs of approximately \$7.5 per hour, and under the highest use option, will need total replacement in 3.5 years.
 - The tractor will have operating costs of approximately \$15 per hour, and under the highest use option, will need a major engine and running gear overhaul during its 15 year lifetime.
 - The animal is assumed to need no overhaul during its useful life – in fact, the more it is used (up to a point) the healthier it will be. When working, the animal is assumed to need \$1.00 of supplemental grain per hour of work.
 - The implements for the tractor and animal are assumed to endure for the entire 15 years .
- The outcomes from table 5 are inputs for table 4. In future drafts, the order of these tables will be reversed.

Conclusions

The lowest capital weeding option by far is a hand hoe. It is, however, the most costly option for major weeding in all three size farm operations considered. (It is fair to acknowledge that hoe weeding will probably always be necessary to some degree.) The second highest cost option in all three cases is the rototiller. The mid-cost option in all three size farms is the tractor option.

The least cost option for the smallest size farm is the wheel hoe. For the middle and largest size operations, the draft animal is the lowest cost option – in both cases significantly lower cost than hand hoe and rototiller weeding.

The cost of the draft animal and tractor options could decrease if either of these traction units were also used for other work on the farm (major tillage, mowing, hauling & spreading, etc).

The input information and assumptions for this analysis are based on the best information I had available. I would welcome information from others regarding this study.

Allen G. Edwards
edtreefarm@gmail.com

Table 1
Overhead cost per year for cultivation options

Cultivation option	Capital cost	Lifetime	Annual depreciation	Annual interest	Capital Overhead per year
Hand hoe	\$30.00	5 years	\$6.00	\$2.10	\$8.10
Wheel hoe	\$400.00	10 years	\$40.00	\$28.00	\$68.00
Rototiller	\$3,000.00	7 years	\$430.00	\$210.00	\$640.00
Tractor	\$20,000.00	15 years	\$1,167.00	\$1,400.00	\$2,567.00
Animal (mule or horse)	\$3,000.00	15 years	\$200.00	\$210.00	\$410.00

Notes

- 1 tractor residual value = \$2500
- 2 Annual interest = 7%

Table 2
Non Capital overhead per year

Cultivation option	Material	Farm labor	Outside labor required	Total
Hand hoe	\$0.50	\$30.00		\$30.50
Wheel hoe	\$0.50	\$30.00		\$30.50
Rototiller	\$25.00	\$75.00	\$75.00	\$175.00
Tractor	\$50.00	\$150.00	\$200.00	\$400.00
Animal (mule or horse)	\$600.00	\$1,875.00	\$150.00	\$2,625.00

Table 3
Time required to cultivate 100' of 30" row

Cultivation option	Sq ft per sec	Sq ft/100' of row	Time in minutes	Cost (@ \$15/hr)
Hand hoe	0.2	250	20.8	\$5.20/100' of row
Wheel hoe	0.67	250	6.2	\$1.55/100' of row
Rototiller	1	250	4.1	\$1.04/100' of row
Tractor	7.5	250	0.56	\$0.14/100' of row
Animal (mule or horse)	7.5	250	0.56	\$0.14/100' of row

Table 4
Direct Time and cost of work

	100,000' row		500,000' row		1,000,000' row	
Cultivation option	Time (hours)	Cost	Time (hours)	Cost	Time (hours)	Cost
Hand hoe	346.67	\$5,200.00	1733.33	\$26,000.00	3466.67	\$52,000.00
Wheel hoe	103.33	\$1,550.00	516.67	\$7,750.00	1033.33	\$15,500.00
Rototiller	68.33	\$1,025.00	341.67	\$5,125.00	683.33	\$10,250.00
Tractor	9.33	\$140.00	46.67	\$700.00	93.33	\$1,400.00
Animal (mule or horse)	9.33	\$140.00	46.67	\$700.00	93.33	\$1,400.00

Table 5
Equipment operating costs per year

		100,000 ft/row		500,000 ft/row		1,000,000 ft/row	
Cultivation option	cost/hour	Hrs per year	cost/year	Hrs per year	cost/year	Hrs per year	cost/year
Hand hoe	\$0.05	346.67	\$17.33	1733.33	\$86.67	3466.67	\$173.33
Wheel hoe	\$0.20	103.33	\$20.67	516.67	\$103.33	1033.33	\$206.67
Rototiller	\$7.50	68.33	\$512.50	341.67	\$2,562.50	683.33	\$5,125.00
Tractor	\$15.00	9.33	\$140.00	46.67	\$700.00	93.33	\$1,400.00
Animal (mule or horse)	\$10.00	9.33	\$93.33	46.67	\$466.67	93.33	\$933.33

Table 6
Sum of annual costs for 100,000 feet of row cultivation

Cultivation option	Capital Overhead/year	Non-Cap overhead/yr	Equip ops cost/year	Direct labor costs/yr	Summary cost/year
Hand hoe	\$8.10	\$30.50	\$17.33	\$5,200.00	\$5,255.93
Wheel hoe	\$68.00	\$30.50	\$20.67	\$1,550.00	\$1,669.17
Rototiller	\$640.00	\$175.00	\$512.50	\$1,025.00	\$2,352.50
Tractor	\$2,567.00	\$400.00	\$140.00	\$140.00	\$3,247.00
Animal (mule or horse)	\$410.00	\$2,625.00	\$9.33	\$140.00	\$3,184.33

Table 7
Sum of annual costs for 500,000 feet of row cultivation

Cultivation option	Capital Overhead/year	Non-Cap overhead/yr	Equip ops cost/year	Direct labor costs/yr	Summary cost/year
Hand hoe	\$8.10	\$30.50	\$86.67	\$26,000.00	\$26,125.27
Wheel hoe	\$68.00	\$30.50	\$103.33	\$7,750.00	\$7,951.83
Rototiller	\$640.00	\$175.00	\$2,562.50	\$5,125.00	\$8,502.50
Tractor	\$2,567.00	\$400.00	\$700.00	\$700.00	\$4,367.00
Animal (mule or horse)	\$410.00	\$2,625.00	\$46.67	\$700.00	\$3,781.67

Table 8
Sum of annual costs for 1,000,000 feet of row cultivation

Cultivation option	Capital Overhead/year	Non-Cap overhead/yr	Equip ops cost/year	Direct labor costs/yr	Equipment extra	Summary cost/year
Hand hoe	\$8.10	\$30.50	\$173.33	\$52,000.00	\$0.00	\$52,211.93
Wheel hoe	\$68.00	\$30.50	\$206.67	\$15,500.00	\$0.00	\$15,805.17
Rototiller	\$640.00	\$175.00	\$5,125.00	\$10,250.00	\$429.00	\$16,619.00
Tractor	\$2,567.00	\$400.00	\$1,400.00	\$1,400.00	\$333.00	\$6,100.00
Animal (mule or horse)	\$410.00	\$2,625.00	\$93.33	\$1,400.00	\$0.00	\$4,528.33



Farmers' Markets: Marketing and Business Guide

A Publication of ATTRA - National Sustainable Agriculture Information Service • 1-800-346-9140 • www.attra.ncat.org

By Janet Bachmann
NCAT Agriculture
Specialist
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The number of farmers' markets has increased dramatically in the U.S. during the past two decades. This publication is a resource for those who want to organize a farmers' market, to improve an existing market, or to increase their sales.

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Farmers' markets are one of the most exciting trends in America's food system. Go downtown in almost any town or city in America during the summer, and you will see signs for the local farmers' market. Read any farm publication examining new marketing opportunities for farmers, and farmers' markets will be addressed. Talk with any public official interested in providing fresh nutritious food to inner city residents, and farmers' markets will be mentioned. Farmers' markets are important because they give local farmers the chance to sell food they raise directly to customers; they allow consumers to buy fresh food from the farmers who raise it; they help create new farms and food businesses; they provide communities ways to create excitement and activity in downtowns and neighborhoods; and most importantly, they give us all the opportunity to think about what goes into producing our food supply. These reasons explain why farmers' markets are one of the fastest growing forms of farm marketing in our nation.

—Neil Hamilton, *Farmers' Markets: Rules, Regulations and Opportunities*

Introduction

Farmers' markets are an ancient method used by farmers worldwide to sell their produce directly to consumers. As U.S. food production became increasingly industrialized and specialized, farmers' markets were replaced by brokers and supermarkets. During the past couple of decades, however, farmers' markets have rapidly regained popularity in the U.S.

Farmers find a number of advantages in selling at farmers' markets. By selling directly to their customers without going through middlemen, farmers can charge retail prices for their produce. A farmers' market is a good place for new growers who are perfecting production skills and learning which products customers want most. In addition, many growers enjoy the interaction with customers and other vendors, and say, "This is my social life."

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For customers, too, the farmers' market is not just a place to buy food, but a social affair. A festive atmosphere helps to bring people to markets, where they can talk with farmers about how the produce was grown and how it can be prepared.

Organizing a new market

A new market is often started by a small group of people who recognize the potential benefits for their community and for local producers. Although markets are sometimes established with as few as three to five regular vendors, a larger number of vendors generally will draw more customers. Your local Cooperative Extension Service or county agricultural commissioner may be able to help you compile a list of potential vendors to invite to your first organizational meeting. Use local news media to help publicize your intentions.

Although some markets may be very informally organized, a set of bylaws, rules, and regulations will help to prevent problems down the road. Following are some of the issues to be addressed:

- **Leadership.** Who will serve on the board of directors? Some market boards are made up entirely of vendors, while some include other people from the community.
- **Management.** Will the manager be a market member or hired from outside the market? What are the terms of employment? What are the responsibilities?
- **Vendor membership.** Who can be a member and vendor? Are there geographic restrictions?
- **Location.** Is the market site easily accessible, aesthetically pleasing, and highly visible? Does it have shade from trees or a structure to provide protection from the elements? Does it provide adequate parking and display space for vendors? Are electricity, water, and restrooms available?

- **Hours, days, and months of operation.** When is the market open? At what time on a market day do vendors need to be in their assigned spaces? When do the spaces need to be vacated?
- **Fresh products.** Will you have a producers-only market, with vendors selling only produce, meats, and plants grown on their own farm? Or will farmers sell what they grow, along with products from other local farms? Or will vendors sell any products they can purchase, locally or not, acting essentially as brokers?
- **Value-added products.** Will these be made primarily from vendor-grown produce? Will wine be allowed? How do state and federal agencies regulate production and marketing?
- **Arts and crafts.** Will these be allowed? If so, will they be juried or limited in number?
- **Containers, weights, and measures.** Are these regulated in any way by the state?
- **Space assignments.** How will spaces be assigned for the season? Seniority, number of markets attended the previous year, and sales volume are used in some markets.
- **Space and membership fees.** What is fair for both large- and small-volume vendors? What does the market need to operate? Some markets charge a flat rate per space, others charge a commission based on total sales. Most markets also have a membership fee.
- **Pricing.** How will you ensure competitive pricing? It may take an educational effort to promote harmony, cooperation, quality, and presentation among vendors and discourage price fixing. Most markets insist that vendors post their prices.

Related ATTRA Publications

Direct Marketing

Market Gardening:
A Start-Up Guide

Postharvest
Handling of Fruits
and Vegetables

Adding Value to
Farm Products:
An Overview

Keys to Success
in Value-Added
Agriculture

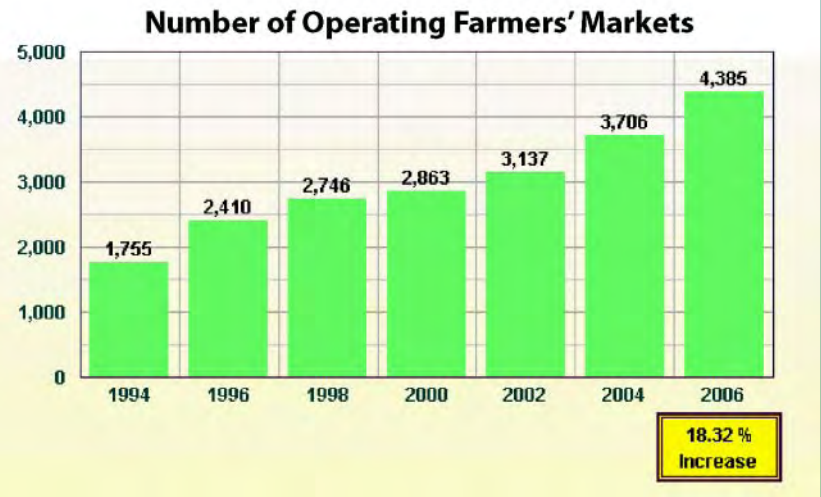
- *Process for dealing with infractions of rules.* How can the rules be enforced fairly, firmly, and consistently? How can a member appeal a penalty?
- *Local and state regulations.* How is the market affected by health and safety standards for food handling?
- *Insurance.* Physical liability insurance in case of injuries or accidents can be purchased by the market or by individual vendors.

Appendix I and materials listed under **Additional Resources** provide additional details and ideas for organizing a new market.

An established farmers' market can be among the jewels of a community, and for this reason should have strong support from the Chamber of Commerce or economic development council. Cities often provide space for a market free-of-charge. They can also help promote special events that draw customers both to the market and to shops in the vicinity. The city may be willing to construct shelters to give vendors and customers protection from rain and sun.

Farmers' markets growth

In 1994, the U.S. Department of Agriculture (USDA) began publishing the National Directory of Farmers Markets which lists all farmers' markets operating in the U.S. Since that time, USDA has updated the Directory every two years. The following graph shows the number of markets at each update.



From USDA Agricultural Marketing Service, www.ams.usda.gov



Pop-up tents offer shade for farmers at an Austin, Texas market. Photo by Jim Lukens.

Is a Farmers' Market the Right Market for You?

Are you a “people person?” Do you want to interact with customers?

- A farmers' market is as much about building relationships as it is about selling products.

Do you (or another family member or employee) have time to be away from the farm?

- Market days are long days for most vendors, who must pack their products, drive to the market, set up a display, meet and greet customers, pack up the display and any left-over produce, return home, and unpack.

Do you have a vehicle suitable for taking your farm products to the market?

- A beginning vendor may bring everything in a compact car, but as the business grows, many vendors look for a cargo van or box truck.

Farmers' markets are much more than just a place to sell food. They have become important community institutions. They are a venue for socializing, where urban residents meet farmers and their neighbors. They have figured in the revitalization of downtown districts, bringing people into areas that were once vacant on Saturday mornings. They serve an educational function, too, helping people learn to eat better.

The success of farmers' markets in general is great news for you as a farmer. It means you're entering a well-established and well-regarded marketing system with great potential for growth. But even at the most successful farmers' markets, success for you individually is more likely if you meet certain criteria. Here are some of the aspects that are of chief importance:

- At the base of all your efforts is quality. You must offer the highest-quality products. Food must be fresh, delicious, and handled with care. Flowers must be vibrant and long-lived. Everything you sell must be clean and packaged properly. Make no mistake about this—you won't succeed if you don't have good food and flowers. Every other marketing strategy depends entirely on your quality.
- Pricing must be appropriate. You must be a student of prices, keeping track of what your customers are paying for the items you sell. What would they pay at the supermarket or the florist? What would they pay elsewhere at your farmers' market? You must know the value of your product and set fair prices—enough for you to be profitable while being competitive.
- Merchandising is important, too. There are dozens of tricks of the trade that will inspire confidence in your products. You need to display your produce in a neat, well-organized and eye-catching manner.

A recent case study in California compared marketing costs of three farms selling by wholesale, CSA, and farmers' market. All three farms were well-established, diversified organic growers in Northern California—one small (20 acres, 2 full-time employees); one medium (70 acres, 7 employees); and one larger (240 acres, 30 employees). Across all three, labor was the highest marketing expense. For the small farm, labor was 77 percent of all marketing costs, ranging from 67 percent in wholesale to 82 percent for farmers' markets. Farmers' markets generated the lowest net revenue return for all three growers, while wholesale provided the highest net return for all. The study points out that price premiums at farmers' markets are not pure profit. (Hardesty, 2008).

Hardesty, Shermain. 2008. Case study compares marketing costs of farms selling wholesale, CSA, and farmers' market. Small Farm News. p. 4.

Personal success at a farmers' market

A successful market depends on successful vendors. Lynn Byczynski, editor and publisher of *Growing for Market*, put together a special issue in 2001 on how to be successful at farmers' markets. The following is excerpted from her introduction.

- Sampling can be an important sales tool, but you need to know what is allowed. Rules about sampling are all geared toward preventing food-borne illness. (The Arkansas Department of Health, for example, allows samples of uncut fruits and vegetables, but cut samples must be prepared in a certified kitchen.) If you provide samples, practice good hygiene, such as using disposable gloves, covering your samples, and distributing samples in such a way that customers' hands don't come in contact with the food.
- The personality of the grower is one of the most important elements to success. Gregarious farmers—those who like to meet new people and talk about their food and farms—will always do better than the quiet types. Friendliness, courtesy, and respect for the customers will win you a loyal following. People come to farmers' markets seeking social interactions, and the more you can help them accomplish that, the better you will do.

The farmers' market issue of *Growing for Market* can be downloaded from the website www.growingformarket.com. And Buczynski's new book, *Market Farming Success*, has an excellent section on farmers' markets. See **Additional Resources**.



An artistic hand-crafted sign identifies this vendor's spot. Photo by Jim Lukens.



A beautiful location is an advantage. Photo by Jim Lukens.

Promoting your market

Champagne PR on a Beer Budget: Grass-roots ways your market can make a marketing splash! was a session presented by a New Orleans public relations professional, Diana Pinckley, at a 2004 workshop on managing a farmers' market (The Four Ms of Farmers' Markets, organized by the Economics Institute of Loyola University; see Twomey Center for Peace through Justice in the **Additional Resources** section at the back of this publication). Ms. Pinckley helped the Crescent City Farmers' Market establish and implement their marketing plan.

After talking about how to figure out what your message is, who you want to hear it, and what you want them to do in response, Ms. Pinckley focused on how to deliver the message. She said paid advertising is generally too costly and ineffective to be considered as a major part of a marketing plan for a farmers' market. Ms. Pinckley emphasized what she called "The Four Ws" of getting a message out:

- Word of mouth
- Work the media to get them to cover your message as news
- Web strategy that works for both external and internal audiences

- Well-chosen print pieces such as newsletters, brochures, flyers, and postcards

Why is word of mouth so important? In this time of excessive hype, we all protect ourselves by tuning out advertising, and then being skeptical of what we do pay attention to. Word of mouth is the most effective delivery method. When you hear something from somebody you know and trust, the message comes with built-in credibility.

Word of mouth is low cost in terms of dollars. It does, however, require an investment of time by everyone associated with the market—especially the vendors. Each vendor needs to be ready and eager to be friendly and help customers enjoy the market when they are attending it, as well as to tell people about the market when they see them in a store, at the ballgame, at church, or in an elevator. In fact, Ms. Pinckley said, “Everybody needs to know an elevator pitch.”

An elevator pitch is a 30-second, distinctive, compelling explanation of what the market is and what it means to you. (Imagine that you have the time it takes to ride with someone in an elevator from the first floor to the third floor.) How do you describe it, hitting the most important points in a few words? “Practice it,” advises Pinckley.



“SalsaFest” tomatoes at the Fayetteville, AR, Farmers’ Market . Everyone is happy when local tomatoes ripen. Photo by Jim Lukens.

Selected farmers’ market Web sites:

- www.ferryplazafarmersmarket.com
- www.carrborofarmersmarket.com
- www.santafefarmersmarket.com
- www.davisfarmersmarket.org
- www.desmoinesfarmersmarket.com
- www.fayettevillefarmersmarket.com

How do you get the media to cover your message as news? Events are one way. Opening day of the market should be a big one. To many regular customers, opening day marks the real beginning of spring. At the Fayetteville Farmers’ Market in northwest Arkansas, opening day coincides with a free tree distribution sponsored by the city. This brings tremendous crowds. Other events can be planned around a special product at the peak of the season. In Fayetteville, SalsaFest in mid-July celebrates the abundance of tomatoes and peppers grown by vendors, who contribute dozens of varieties for a tomato and pepper “museum.” Restaurants serve samples of their unique salsas, musicians play Latin rhythms, and a salsa dance instructor gets people dancing. Events do not necessarily translate to more dollars spent on the day of the event, but they do serve to bring out the media—and newcomers, who are likely to come back.

Marketing the Market, a Kansas Rural Center Sustainable Agriculture Management Guide, also highlights ways to promote markets on a limited budget. The six-page

guide emphasizes the most important part of marketing the market: efforts by individual vendors. See **Additional Resources** for obtaining a copy.

Evaluating your market

Just as for any other business, you need to evaluate your farmers' market on a regular basis. There are a number of ways you can involve vendors, customers, and management.

Customer surveys

Mystery Shopping at the Crescent City Farmers' Market is adapted from common practices in large retail companies. Mystery shoppers are people who are recruited to report to the management about the experience of shopping in a given place. This is a way to get feedback on a market from regular or new shoppers. A copy of the form used at the Crescent City Farmers' Market is in **Appendix 2**. It includes instructions for the shoppers. You can adapt the form for your own market.

Formal surveys can be designed to learn why people shop at the market, how often they attend, how far they travel, their most important reasons for shopping, how they learned about the market, how much they spend, and their age, sex, ethnicity, level of education, and annual household income. Such a survey should be kept as short and simple as possible.

Dot Surveys ask a limited number of questions displayed on flip charts. Customers indicate their responses using colorful self-stick circles or "dots." One advantage of this technique is that people enjoy it. A weakness is that respondents may be heavily influenced by previous postings. Details on how to set up Dot Surveys can be found in the Oregon State University publication *Tools for Rapid Market Assessment*, online at www.oregonfarmersmarkets.org/create/marketresearch.html.

Pedestrian counts

Counts of the number of people entering your market give you interesting information. The



NCAT's Midwest Field Office Director Holly Born used the Dot Survey technique at the St. Paul, Minnesota market in 2007. She says people at the market really enjoyed "doing the dots." Several told her they never knew a survey could be fun. Photo by Holly Born.

tools needed include clip boards, tally sheets, pencils, and tally counters. Finding enough volunteers so that none has to work for more than 2 hours and so that each entry point has one person counting is perhaps the biggest challenge. By breaking the tally sheets into 15 minute segments, you can verify peak hours of customer traffic. Do the counts several times throughout the season and on days with events and without events.

Another way to do pedestrian counts is to have the manager or a volunteer walk through the market at one hour intervals and count all visitors present. This will not give you a total number of pedestrians, but can give you figures to compare attendance from day to day and year to year. *Tools for Rapid Market Assessments*, above, also has details and ideas for customer counts.

Vendor surveys

How do you involve your members in market decisions? Surveys can encourage vendors to express their ideas, concerns, and satisfaction. Dot Surveys work just as well with market members as with customers. Try this at your next member meeting. Also see **Appendix 3**, Farmers' Market Vendor Evaluation.

Financial

It is important to document the business of farmers' markets. By recording the number of vendors per market, sales per vendor, and total sales, you can track the success—or lack of success—of a market. Sales records are easy to obtain if the market fee is based on sales. FRESHFARM Markets in the Chesapeake Bay region, for example, has a fee of 6% commission. With this data, you can show the impact of your market on the income of farmers and the importance of the market to the community.

SWOT analysis

SWOT is a planning tool that can be used in a business context by a market's board of directors or committees, or in a personal context. SWOT stands for:

Strengths
Weaknesses
Opportunities
Threats

Strengths and weaknesses are internal factors. Opportunities and threats are external factors. **Appendix 4** provides a chart for listing these.

Strengths may be things like a large diversity of fresh locally grown products at the market, a committed and thoughtful board of directors, and financial stability.

Weaknesses may be things like lack of consensus on vision for the market, poor record keeping, or poor displays.

Opportunities offer new chances for success. These might be new products, new partnerships with other businesses or organizations, and more interest by the public in local products.

Threats may be dogs at the market, a perceived lack of parking spaces, or competition from big box stores. (Sometimes a threat can be turned into an opportunity.)

Once you have the SWOT analysis on paper, you need to plan for how to deal with the items you listed. Each of these plans needs to be discussed so that you get ideas from everyone involved. When all players have helped to create a written plan, you can do a better job.

What makes SWOT particularly powerful is that with a little thought, it can help you uncover opportunities that you are well placed to exploit. And by understanding the weaknesses of your business, you can manage and eliminate threats that would otherwise catch you unawares.

Even more than this, by looking at yourself and your competitors using the SWOT framework, you can start to craft a strategy that helps you distinguish yourself from your competitors. This will help you compete successfully in your market.

Strength in numbers: state associations

"Farmers' markets are definitely here to stay, and they continue to expand and are an important direct marketing strategy for farmers," says Randii MacNear, manager of the Davis Farmers' Market in Davis, California. "It's important for us as managers to be as effective as possible. We have so much to learn from each other. It's important to stay in touch and become united so we have a voice in issues important across the United States and Canada. We need strength in numbers."

State farmers' market associations are forming around the country. Many are aimed at assisting current markets and coordinating the development of new ones. But they can also serve as a united voice to promote governmental actions that support farmers' markets—or to prevent actions that will harm them. See **Appendix 5** for an example of what one state association (New Mexico) offers its members and **Appendix 6** for a list of state associations.

Additional Resources

National organizations and agencies

Farmers' Market Coalition
Stacy Miller, Executive Secretary
304-685-2669

stacy@farmersmarketcoalition.org
www.farmersmarketcoalition.org

The FMC grew out of the North American Farmers Direct Marketing Association, and evolved to become a separate 501(c)3 organization. The mission of the FMC is to strengthen farmers' markets for the benefit of farmers, consumers, and communities. The membership fee is \$25 per year for individual markets.

Project for Public Spaces
700 Broadway, 4th Floor
New York, NY 1003
212-620-5660

www.pps.org

Project for Public Spaces is a nonprofit organization dedicated to helping people create and sustain public spaces that build stronger communities. It has managed grants to fund a number of farmers' market projects around the country.

Twomey Center for Peace through Justice
Loyola University, New Orleans, Louisiana
www.marketumbrella.org

The Twomey Center initiates and promotes the ecology of local economies through the four M's: managing markets, mobilizing citizens, mentoring leaders, and modeling best practices. The organization promotes the simple, traditional, and enjoyable world of public markets because it believes that in these ancient mechanisms lie the seeds for a brighter, greener future.

Wallace Center Winrock International
Matthew Kurlanski, Research Associate
1621 N. Kent Street
Arlington, VA 22209
703-525-9430 ext.671, MKurlanski@winrock.org
www.wallacecenter.org

www.wallacecenter.org/our-work/current-initiatives/national-farmers-market-network

In 2007, the Wallace Center led a collaborative effort involving 12 partners from around the U.S. to develop resources for farmers and farmers' market managers. One result is a pair of handbooks, Getting Started with Farmers' Markets and Recruiting for a Farmers' Market. They can be downloaded from the Web, or will be sent upon request. For copies of the handbooks,

or information about the ongoing initiative, contact them.

USDA/Agricultural Marketing Service
Velma R. Lakins, Marketing Specialist
1400 Independence Ave.
Room 2646-S, Stop 0269
Washington, D.C. 20250-0269
202-690-8103

velma.lakins@usda.gov

www.ams.usda.gov

The USDA/AMS offers programs, publications, and more to assist farmers' markets. A few of the programs are described below. Go to the website to see what is currently available.

The Women, Infants, and Children (WIC) Farmers' Market Nutrition Program (FMNP), established in 1992, is a federal program that benefits both vendors and low-income customers. It provides special coupons to WIC participants, which they can use to purchase fresh fruits and vegetables at participating farmers' markets. The program has two goals:

- *To provide fresh nutritious unprepared food such as fruits and vegetables to WIC participants who are at nutritional risk*
- *To expand consumer awareness and use of farmers' markets*

During fiscal year 2005, 14,323 farmers, and 2,715 farmers' markets and 1,999 roadside stands were authorized to accept FMNP coupons. Coupons redeemed through the FMNP resulted in over \$23 million in revenue to farmers for fiscal year 2005.

Each state agency is responsible for authorizing individual farmers, farmers' markets, or both. The FMNP contact person for each state agency can be found at www.fns.usda.gov/wic/Contacts/farm.htm.

The Senior Farmers' Market Nutrition Program (SFMNP) awards grants to States, United States Territories, and federally recognized Indian tribal governments to provide low-income seniors with coupons that can be exchanged for eligible foods at farmers' markets, roadside stands, and community supported agriculture programs. Go to the website www.fns.usda.gov/wic/SeniorFMNP/SFMNPmenu.htm for more details and to learn whether the program is operating in your state.

The Food Stamp Program helps low-income people and families buy the food they need for good health. Benefits are provided on an electronic card that is used like a credit card in grocery stores and farmers' markets

that have been authorized to accept them. The 2006 EBT Farmers' Market Projects Status Report describes how markets around the country are using EBT: www.fns.usda.gov/fsp/ebt/ebt_farmers_markstatus.htm.

At the Midtown Public Market in South Minneapolis, 30 local growers are accepting tokens from food stamp clients. The Market is open on Saturdays from May through October. From mid-July to late October, the market also operates on Tuesdays. Another associated market, the Midtown Global Market, operates on Thursdays with 15 vendors. Patrons use \$1 tokens, which can be purchased at a central location within the market. The market advertises its ability to accept food stamp transactions through signage at the market, as well as through flyers, information provided during nutrition classes, and at exhibitor tables at local events. The market works with other local nonprofit and community organizations to spread the word. The state mailed a flyer to approximately 500 households in the area surrounding the markets. The flyer provided information about the use of EBT at the two markets, along with a colorful brochure about healthy eating. The project received support from a Project for Public Spaces grant with funding from the WK Kellogg Foundation.

The NCAT website also provides information about EBT at www.ncat.org.

The Farmers' Market Promotion Program (FMPP) provides grants to help eligible entities improve and expand domestic farmers' markets, roadside stands, community-supported agriculture programs, and other direct producer-to-consumer market opportunities. Eligible entities under the FMPP program include agricultural cooperatives, local governments, nonprofit corporations, public benefit corporations, economic development corporations, regional farmers' market authorities, and Tribal governments. In federal year 2006, approximately \$1 million was allocated for the program with a maximum amount of \$75,000 awarded for any one proposal. Go to the Farmers Market Promotion Program Web site for information: www.ams.usda.gov/fmp

USDA Risk Management Agency
USDA/RMA
Mail Stop 0801
1400 Independence Ave., SW
Washington, DC 20250-0801
www.rma.usda.gov

The RMA's Community Outreach and Assistance Partnership Program may be of interest to farmers' market members. The competitive grants program is designed for activities that will improve markets and reduce risks. www.rma.usda.gov/news/2008/01/outreach.pdf

USDA Cooperative State Research, Education, and Extension Service
USDA/CSREES
1400 Independence Ave., SW Stop 2201
Washington, DC 20250-2201
www.csrees.usda.gov

CSREES supports community food projects that meet the food needs of low-income people, that increase the self-reliance of communities in providing for their own needs, and that promote responses to local food, farm, and nutrition problems. It also supports efforts to develop state, local, or neighborhood food and agriculture infrastructure, plan for long-term solutions, and create innovative marketing activities that benefit agricultural producers and low-income consumers.

Books

The New Farmers' Market. 2001. By Eric Gibson, Marcie Rosenzweig, and Vance Corum. New World Publishing, Auburn, CA. 272 p.

Available for \$24.95 plus shipping.

The Legal Guide for Direct Farm Marketing. 1999. By Neil D. Hamilton. Drake University Law School, Des Moines, IA. 235 p.

Available for \$20 plus shipping.

Farmers' Markets: Rules, Regulations and Opportunities. 2002. By Neil D. Hamilton. National Center for Agricultural Law Research and Information Center. 47 p. www.NationalAgLawCenter.org

Covers fundamental issues that must be addressed by all farmers' markets, regardless of their size or complexity: who administers the market, who determines who can sell what, how the market will operate.

Grassroots Marketing: Getting Noticed in a Noisy World. 2000. By Shel Horowitz. 306 p.

A resource for any kind of small business, including horticultural businesses, the book has ideas for low-cost or free publicity. Topics include creating an image; how to write ad copy and press releases; tricks of the printing trade to save money on brochures and ads; direct mail; selling on the Internet; working with the media; and much more. \$22.95 plus shipping.

Dynamic Farmers' Marketing. 1997. By Jeff Ishee. Bittersweet Farmstead, Middlebrook, VA. 130 p.

Available for \$14.95 plus \$2.50 shipping from:

*Bittersweet Farmstead
P.O. Box 52
Middlebrook, VA 24459
540-886-8477*

Market Farming Success. 2006. By Lynn Byczynski. Fairplain Publications, Lawrence, KS. 138 p.

Available for \$20 plus \$3 shipping from:

Fairplain Publications Inc.

Growing for Market

P.O. Box 3747

Lawrence, KS 66046

800-307-8949

www.growingformarket.com

Publications from an Organization or Agency

Selling Strategies for Local Food Producers. 2007.

By Bill McKelvey, Mary Hendrickson, and Joe Parcel. University of Missouri Extension, Columbia, MO. 8 p. <http://extension.missouri.edu/explore/agguides/hort/g06222.htm>

Starting a Seasonal Open-Air Market in Kansas: A Market Organizer's Field Guide. 2007. By Claire Homitsky, Kansas Rural Center; and Jana Beckman, K-State Research and Extension, Kansas State University, Manhattan, KS. 22 p. www.oznet.ksu.edu

Marketing the Market. By Jerry Jost and Mercedes Taylor-Puckett. The Kansas Rural Center. 6 p. Online at www.kansasruralcenter.org/publications.

A must-read for farmers' market members, boards, and managers. Printed copies are available from:

Kansas Rural Center

P.O. Box 133,

Whiting, KS 66552

785-873-3431

Step-by-Step Guide for Establishing a Farmers' Market Association. By Diane Eggert, Farmers' Market Federation of New York. 11 p.

Includes sample bylaws and member agreement.

117 Highbridge Street, Suite U-3

Fayetteville, NY 13066

315-637-4690

www.nyfarmersmarket.com

Establishing and Operating a Community Farmers' Market. 1992. By Forrest Stegelin. University of Kentucky Cooperative Extension Service. 8 p.

Getting Started with Farmers' Markets. 2008. Wallace Center, Winrock International. 28 p.

A simple and brief guide to show farmers how other farmers have worked to make their farms profitable by selling some or all of their products at farmers' markets. See address under National Organizations.

Recruiting Vendors for a Farmers' Market. 2008.

Wallace Center, Winrock International. 24 p.

This guide is designed to help show how market managers diversify their vendor and customer bases to grow their markets. See address under National Organizations.

Understanding Farmers' Market Rules. 2006. By Jess Anna Speier and Jill E. Krueger. Farmers' Legal Action Group. 8 p.

Intended to help farmers understand their responsibilities and rights as vendors at a farmers' market. Also highlights some of the relevant federal, state, and local laws that may apply.

FLAG

360 North Robert Street, Suite 500

St. Paul, MN 55101-1589

651-223-5400

lawyers@flaginc.org, www.flaginc.org

Periodicals

Growing for Market

P.O. Box 3747

Lawrence, KS 66046

800-307-8949

www.growingformarket.com

Growing for Market is a monthly publication about growing and direct marketing vegetables, fruits, herbs, cut flowers, and plants. It covers farmers' markets, Community Supported Agriculture, the local food movement, organic growing, cut flowers, and much more. Print subscriptions are \$33 per year, or 2 years for \$60. Check the website for online subscriptions.

Farmers' Markets Today

Scissortail Productions LLC

120 W. 4th St. Ste. A

Cedar Falls, IA 50613-2832

info@scissortailProductionsLlc.com

www.FarmersMarketsToday.com

Published bimonthly, Farmers' Markets Today subscriptions are \$33.95 per year.

Market Farming e-mail discussion group

<http://lists.ibiblio.org/mailman/listinfo/market-farming>
Market Farming provides the small-scale farmer a way to network with other farmers, to discuss appropriate scale production methods, equipment, marketing, profitability, cropping sequences, diversification, sustainability, working with extension agents, private consultants, and fellow farmers, and anything else involved in making a living and providing food and fiber from your small acreage farm. To see the collection of prior postings to the list, visit the Market-farming Archives.

Related ATTRA Publications

Get a free printed copy of ATTRA publications by calling 800-346-9140, or download from the ATTRA web page: www.attra.ncat.org

Direct Marketing. 1999. By Katherine Adam, Radika Balasubrahmanyam, and Holly Born. 36 p.

Market Gardening: A Start Up Guide. 2008. By Janet Bachmann.

Postharvest Handling of Fruits and Vegetables. 2000. By Janet Bachmann and Richard Earles. 28 p.

Adding Value to Farm Products: An Overview. 2006. By Holly Born and Janet Bachmann. 12 p.

Keys to Success in Value-Added Agriculture. 2001. By Holly Born. 20 p.

Appendix 1

Market rules that work

Trina Pilonera, Silver Heights Farm

216 Egger Road

Jeffersonville, NY 12748

845-482-3608

Member, Board of Directors, Sullivan County Area Farmers' Market, Inc. (SCAFM)

Member, Governing Council, Northeast Organic Farming Association—New York

Farmers' markets come in all sizes, with a multitude of purposes, organized by many different groups and individuals, and serve many different kinds of communities. Without some form of guidance, markets can become highly disorganized and fall apart.

Mission statement

Before developing any rules, the organizers of a market need to answer several questions about their particular market. Why is this market being created? What is the purpose or philosophy of this particular market? Who will benefit from this market? A mission statement for the market answers these questions:

- (This market) is here to serve (this community) by providing locally grown, fresh, high quality produce and products, and to provide an opportunity for local farmers, producers, and artisans as an economic outlet within (this community.)

- (This market) is a showcase for locally grown food and other farm-related products, providing an alternative marketing opportunity that allows farmers and consumers to interact directly with each other.
- (This market) provides the opportunity to preserve the connection between farmers and consumer, and to educate consumers about the benefits of preserving local agriculture and the benefits of using locally produced foods.

A mission statement is a statement of purpose. It should be brief, but communicate your values and future vision. Consider who will see your mission statement and bear this in mind as you write. Will you post it somewhere visible for customers to read, like a label or brochure? Notice that in all of these mission statements both providers and consumers of products are identified. The market organizers should understand who the market will be serving on the consumer end.

Rules and regulations

The role of rules is to keep a market intact, define its purpose, and make it possible to be administered in an effective manner. There are no universal guidelines for “the best” set of rules for every market, but there are some general guidelines that every market can consider for developing and enforcing rules.

Market rules define who is eligible to participate as a vendor. Will this be a producer-only market? Will re-selling another's products be allowed? Will value added products be allowed? Will artisans or cottage industries be allowed? Will drop-in vendors be permitted? Will local groups (churches, not-for-profits, 4-H, ...) be permitted to participate on an occasional basis? Will take-home foods be permitted? Will there be entertainment or education? Some markets define what locality the vendors must come from—within a 50-mile radius, within the county or multi-county area, within the state, within a 3-hour drive. Statement of who qualifies as an eligible vendor must be clear so that enforcement cannot be easily challenged.

Market rules define eligible products. Some markets are very specific about what produce and products can be sold. Is the market a produce-only market? Can more than one vendor offer the same produce? Are plants (herbs, bedding, landscape) and cut flowers allowed? Will eggs, meat, honey, maple syrup, jams and jellies, baked goods, wine, soaps and cosmetics be allowed? The larger the market, the more important this parameter becomes. A market with 3 or 4 vendors needs as much product as possible to remain economically viable. A 20-plus vendor market needs to ensure that all vendors have the opportunity to make money without allowing overly intense competition when everyone is selling the same products. So a 20-plus market could benefit from having a value-added aspect beyond produce.

Market rules need provisions that address effective operation of the marketplace.

1. Identify the sponsor or organizer of the market.
2. Identify the day-to-day decision maker (market manager) and define that individual's responsibilities.
3. Enumerate the rules for market operation. Agreeing to abide by the market rules should be part of a legally binding agreement between the vendor and the market, or rules cannot be enforced. Have the applicant sign an agreement to abide by the rules and regulations in the application process. (See #8 for specific kinds of rules.)
4. Vendor and product eligibility are defined. Producer-only or re-sale requirements are defined. Other terms (farmer, other eligible vendors, organic, local) should be defined.
5. Locations of markets are identified. Hours and days of operation are established.
6. Membership fees, space fees, and payment requirements are stated.
7. The application process is clear. The vendor needs to know who reviews each application. Are there any privileges extended to prior vendors, such as space assignment or preference in the acceptance process?
8. Guidelines for selling should include signage for the farm and products, posting of prices and pricing guidelines, whether or not pre-market sales are acceptable, whether a vendor can leave early or arrive late on a market day, arrival times for set-up and times for departure, display space, pets at the market, acceptable representatives of the vendor at the market, cleanliness of the selling space, product quality, courtesy towards customers and other vendors and the manager, deceptive advertising, parking, sampling, hawking, smoking, non-attendance and notification of inability to attend, use of legal scales, specific rules for food handling that may not be covered by local or state regulations, participation in Farmers' Market Nutrition Program (FMNP), allowance for end-of-market discounting (not recommended), compliance with local, state, and federal regulations and laws.
9. Necessary licensing and permits are to be submitted to the organizers as well as displayed at market. (This fits the regulatory aspect of markets for localities and the state.)
10. Define a clear-cut procedure for dealing with violations of rules and

T here are some general guidelines that every market can consider for developing and enforcing rules.

Make a provision for a regular review of rules so that rules remain effective.

regulations. If rules are not enforced, they become meaningless. Establish how and to whom violations are reported and how to notify vendors about the violations (informal spoken, formal written). Establish penalties (suspension or removal after X number of violations, fines). Compliance with rules should be incorporated into the application approval. Can vendors complain about others violating rules? Is there an appeal process?

11. Define insurance requirements. Does the market itself carry insurance? Is it enough that vendors have farm insurance, or should they also name the market as an additional insured? Do vendors also need product liability insurance?
12. Are there provisions for changes in ownership of a vendor's farm or business? Is there a waiting list for eligibility, and seniority on such a list? How are spaces at the market assigned?
13. Develop a hold harmless and indemnification clause acceptable to whoever gives the market legal advice. Decide whether the community should be included. As part of the application process, the vendor should agree that the market organizers and other sponsors are protected from legal and financial liability in accidents and other incidents at the marketplace.
14. Provide for and conduct farm/business inspections to verify that the vendor is producing what they are selling. Decide if a detailed farm plan is necessary for this process. Is there a fee if violations are found with inspection of facilities? Who conducts the inspections?
15. If there is a board of directors for the market organization, how are they elected or appointed to serve? Terms and limitations of offices and types of administrative committees should be defined.

Make a provision for a regular review of rules so that rules remain effective. Rules can be

dropped, changed, and added as needs present themselves. Keep rules as simple as possible. Complicated rules are confusing, often not understood, and hard to enforce if vendors get a headache trying to interpret their meaning. For instance, if absolutely no selling is allowed before market is open, say so. If there are exceptions to selling before market opens, be specific:

Sales before market opens are allowed in the following instances only:

1. Sales to other vendors.
2. Sales to customers who have placed an order at a prior market, and the market manager is notified before the customer is allowed to get the order.
3. Sales with market manager approval only.
4. Violations to these rules will result in a written notification, which can lead to suspension.

Enforcement of a market's rules needs to be fair and consistent. The market manager is given the discretion to issue verbal warnings that have no "teeth" so that the vendor can fall back into compliance without being penalized as long as compliance is immediate. (People do forget rules and regulations, and a reminder is usually all that is necessary.) However, if the market manager decides that the vendor is not responding to the verbal warnings or that the violation is blatant and important, two written warnings in a market season are issued before true financial impact to the vendor is enforced. With the issuance of a third written warning, the vendor is not allowed to attend the market the following week. With the issuance of another warning, the vendor cannot attend any of the four markets they are in during the next 2 weeks. With the issuance of a final warning, the vendor is expelled from the market for the remainder of the season. The vendor continues to owe fees for stall space when suspended.

If you stop and think about rules violations, some violations are considerably more important than others. For instance, not posting prices is not as important as selling spoiled meat. Forgetting to post prices does

not potentially kill a customer, while salmonella in spoiled meat can kill the customer—and the market place. Rules should provide a sliding scale of penalties based on numbers and severity of violations. Markets need to decide if fines should be paid, suspension from whatever number of market days, and expulsion are appropriate.

Furthermore, markets need to provide an opportunity for non-frivolous complaints to be filed by other vendors and by customers without threats of recriminations. Usually, a “heads-up” stated to a market manager should be sufficient, if there is an appropriate enforcement policy handy. Some markets attach a fee that is refundable only if the violation is proven and results in discipline of the offender. This helps cut down on frivolous complaints.

Vendors also must have the right to defend themselves against accusations in front of whatever enforcement group is set up by the market. And those found in violation ought to have the opportunity to appeal decisions. Not all individuals are “nice” to be around, and managers and sponsors may disfavor certain individuals enough to the point of persecution. The right for a hearing helps keep management abuses in line.

When SCAFM was being set up in 1995, we reviewed copies of rules and regulations from other farmers’ markets throughout the state. We earmarked every rule we thought would be pertinent to our market in each set of rules we found. Then, we re-ordered the rules into the following framework:

Mission Statement

General Rules

(how the organization is run)

Items for Sale (Day-to-day operations in the marketplace)

Regulatory Guide (State, local, SCAFM legal requirements)

Insurance

Sanitation

Products

Deceptive Advertising is

Not Acceptable

Deceptive Packaging Is Illegal

Definitions

The rules are reviewed and revised every January by the newly elected Board of Directors. State and local regulations and contact phone numbers are reviewed and updated. Rules can also be revised or added anytime during the year by the Board of Directors.

The application is revised every year. On the application, we have added size of vehicle to help the Market Manager decide where to assign appropriate spaces. We also have requested permission to post appropriate vendor Web sites or e-mail addresses on the SCAFM Web site. The application asks for appropriate information for our database. It includes a checklist so that we receive a complete application from the get-go:

- _____ Completed application
- _____ Completed listing of produce and products
- _____ Membership fees
- _____ Two-week stall deposit fee
- _____ Photocopy of Sales Tax Certificate if you sell taxable items
- _____ Copy of Certificate of Insurance for general (premises and product) liability naming SCAFM, Inc., as an additional insured. (Name & phone of SCAFM insurance agent included.)

The application also includes a Vendor Compliance and Indemnity Agreement with a required signature:

I (we), the undersigned, have read the Rules and Regulations of SCAFM, Inc., and do agree to abide by all these rules and regulations.

I (we) further agree to operate my (our) stall in accordance with these rules and regulations and to pay all applicable fees as set out in the rules and regulations. I (we) do understand that the stall fee, length of season and hours of operations are set in the rules and regulations, and I (we) will abide by them.

Enforcement
of a mar-
ket’s rules
needs to be fair and
consistent.

Rules help interested parties identify the purpose and philosophy of a market.

I (we) further understand that failure to comply with the rules and regulations of SCAFM, Inc., could mean dismissal from the market.

As a vendor wishing to participate in SCAFM, Inc., located in (names of communities), I (we) agree to SAVE, HOLD HARMLESS AND INDEMNIFY, SCAFM, Inc., Cornell Cooperative Extension of Sullivan County and the Town(s) of (names of various local towns) from any an all liability or responsibility pertaining to any damages to person or property on the site assigned to me (us) by SCAFM, Inc., when such damages or liability arise out of acts of my (our) own, or of my (our) employees or associates, located at such site.

The applicant's signature represents a legal binding agreement between the

vendor and the market once the application is approved.

So, rules have a good function in the operation of viable farmers' markets. They help interested parties identify the purpose and philosophy of a market. They set up a framework for day-to-day administration. They provide for disciplinary procedures. The application process creates a legal binding agreement between market and vendor. Rules that are kept simple, are pertinent to a particular market, and are reviewed from time to time can guide a market to success.

SCAFM, Inc., Rules and Regulations can be read on the Web site, www.scafmm.org. Using any search engine, type in "farmers' market rules" and you will get many choices.

Appendix 2

Mystery shopping at the Crescent City Farmers' Market

www.4mworkshop.org/downloads/2005_4M_mystery_shop.pdf



Mystery Shopping at the Crescent City Farmers Market

Welcome to our Market! We are very excited to have so many professional market eyes giving us feedback on our Market. Please feel free to do this exercise in groups; not everyone has to do a separate sheet! Mystery shops are common practice in large retail companies; some corporations have a mystery shop done each month at each location. It is a very useful tool to find out what the shopper sees and experiences. We have found that asking some of our loyal shoppers (and also some new faces) to do MS every once in a while works well. Try to be casual and relaxed. It's very important to not have this paper showing when you are doing the mystery shop. Walk away if you need to write down answers. Please turn in to the box marked MS at the Welcome Booth.

Mystery Shop for Crescent City Farmers Market

Ambience: (Circle Yes or No)

1. Was the entrance well marked with signs? Yes No
2. Is there an information booth? Was it staffed? Yes No
3. Was the merchandise at the information booth priced and available in the size needed? Yes No
4. Did vendor #1 have all products priced? Yes or No
5. Did vendor #2 have all products priced? Yes or No
6. Was the special event advertised at the Market? Yes or No
7. Did you understand what was for sale at both vendor tables? Yes or No
8. Did you feel welcomed by the vendors? Yes or No

Other observations: _____

If you would like, ask 1 question on 2nd page (or a question of your own choosing) to either a vendor or a staff person. Remember there are 60+ of you, so many of the questions have been asked by others!

Efficiency: (Choose one of these questions or one of your choosing)

a) Is the lucky bamboo lady here? _____

b) Are there any events on at this market? _____

c) Can I sell handmade baskets? (my brother uses palm fronds to make very cool baskets...)

d) Do you know where there is an ATM? _____

e) Do you have something that shows where all the Markets are located?

f) Are there bananas here? _____

g) Why don't you come on Saturday mornings? _____

h) Can you sell me stuff wholesale for my restaurant in Baton Rouge?

i) How long have you been here? _____

1. Did the volunteer/staff member answer your question(s)? Yes No

2. Did the volunteer/staff member know about the next special event?

3. Were you able to find out all the information about becoming a vendor? Yes No

4. Was a vendor able to answer your question? Yes No

Appendix 3

Farmers' market vendor evaluation

The Farmers' Market Federation of New York (www.nyfarmersmarket.com) offers many resources including this vendor evaluation form: www.nyfarmersmarket.com/pdf2007/fmvendorevaluation.pdf

	Yes	No	Needs Improvement
Image			
Overall impression is favorable			
Neat, clean, well organized			
Signs with business name			
Proper licenses/permits displayed			
Display Area			
Adequate size for proper display			
Well organized			
Efficient use of available space			
Does not obstruct traffic flow thru the market			
Neat & orderly in front of and behind tables			
Power cords are taped down to prevent tripping			
Food handling is done in a safe & hygienic manner			
Tables, tents and signs are tied down			
Vehicle			
Does not detract from display			
Secured – brakes in tact, no gas or other leaks			
Display Surface			
Clean, attractive			
Stable			
Free of hazard to customer			
Attractive table covering			
Displays			
Proper height/ angle for customer access			
Logical grouping of products			
Fully stocked at all times			
Clean containers, appropriately sized for product			
Variety of unit sizes available			
Tent or canopy to protect the products			
Pricing			
Clear signs so customer knows price			
Appropriate for product			
If sold by weight, appropriately labeled & certified scales			
Taxable items identified properly			
Use of pricing strategies to promote larger sales			

	Yes	No	Needs Improvement
<i>Product</i>			
High quality			
Good variety, including expansion within product line			
Products are clean and wholesome looking			
Non-hazardous food			
Identified by name			
Hazardous foods as permitted & kept at appropriate temps			
Proper labeling as required by law			
sampling			
<i>Cash handling</i>			
Efficiency			
Calculator to add quickly			
Receipts provided where appropriate			
Cash box or other means of collecting money			
Enough change (coins and bills) for market day			
Security provisions			
<i>Customer Service</i>			
Bags			
Recipes			
Taste testing or demonstrations			
Customers encouraged to touch & smell products			
Business cards/farm flyers available for customers			
Complaint policy			
<i>Personnel</i>			
Courteous to customers			
Cheerful, friendly			
Make eye contact/greet customers			
Standing to encourage sales			
Appearance is neat/clean			
Informed about product			
<i>Signage</i>			
Printing is legible & large enough to be easily read			
Signs posted high enough to be seen from a distance			
Signs identify product & other information			
Signs displayed for FMNP, EBT or other coupon programs			

Appendix 4

Strengths, Weaknesses, Opportunities, Threats (SWOT) analysis worksheet

www.mindtools.com/rs/SWOT

Strengths: What do you do well? What unique resources can you draw on? What do others see as your strengths?	Weaknesses: What could you improve? Where do you have fewer resources than others? What are others likely to see as weaknesses?
Opportunities: What good opportunities are open to you? What trends could you take advantage of? How can you turn your strengths into opportunities?	Threats: What trends could harm you? What is your competition doing? What threats do your weaknesses expose you to?

Appendix 5

Services offered by a state association

Services offered by the New Mexico Farmers' Marketing Association to New Mexico Communities

Market Development – We assist communities with starting new farmers' markets.

We support the growth of existing markets, through assistance with organizational development, grower recruitment, finding volunteers, and developing revenue streams to help markets become self-sustaining.

Marketing – Our statewide marketing campaigns increase public awareness of the markets. Promotion efforts include:

- Our promotional web site (visit us at *farmersmarketsnm.org*)
- Farmers' Market Day at the State Fair
- A bi-weekly column, "This Week at the Farmers' Market" in the Albuquerque Journal.
- A four-color state-wide brochure
- Our toll-free information number

We assist markets with local-level promotion, by providing marketing materials, promotional products, a newsletter, and our professionally designed logo.

Partners – We receive base funding from the New Mexico Department of Agriculture in order to promote and develop our markets. We also partner with the New Mexico Economic Development Department, to help markets with advertising, and with the New Mexico Cooperative Extension Service.

The Association works with several national organizations including the National Association of Farmers' Market Nutrition Programs, the Community Food Security Coalition and the North American Farmers' Direct Marketing Association.

Training for Market Managers & Vendors – We hold two annual meetings for our market managers, where we provide training to improve their management and marketing skills. We assist markets with putting on educational workshops for the farmers in their regions.

A Unified Voice in Santa Fe – We work to secure funding for the WIC and Senior Farmers' Market Nutrition Programs. We represent the markets with a strong unified voice at the state legislature.

Networking Opportunities – We provide access to a great network of market managers and staff from our markets across the state, as well as regionally and nationally. We keep our members informed through email, and through periodic bulletins.

Financial Assistance – We offer a grants program to assist our markets with promotion, and with building their market organizations.

Insurance – We offer a competitively priced general liability policy for markets.

Resources Available – *The New Mexico Farmers' Market Manual* contains everything you ever wanted to know about starting a farmers' market in the Land of Enchantment!

Appendix 6

State farmers' market associations

Alabama

Don Wambles, Director
Alabama Farmers Market Authority
770 Washington Ave, Ste 330
Montgomery, AL 36130
Phone: 334-242-2618
Cell: 334-868-9978
Fax: 334-242-0536
don.wambles@fma.alabama.gov

Alaska

Amy Pettit, State Farmers Market
Representative
Alaska Dept. of Agriculture
1800 Glenn Highway, Suite 12
Palmer, AK 99645
Phone: 907-745-7200
Fax: 907-745-7254
Amy.Pettit@Alaska.gov

Arizona

www.arizonafarmersmarkets.com

Arkansas

Arkansas Farmers' Market Association
Jean Jones, President
3004 Linden Avenue
Texarkana, AR 71854
Phone: 870-772-4558
Cell: 903-559-9401
jeanjones@cableone.net

California

California Federation of Certified
Farmers' Markets
P.O. Box 1813
Davis, CA 95617
Phone: 530-753-9999
cafarmersmarkets@dcn.org
www.cafarmersmarkets.com

Colorado

Colorado Farmers' Market Association
Sally Haines
P.O. Box 4354
Boulder, CO 80306
Phone: 303-887-5972
contact08@coloradofarmers.org
www.coloradofarmers.org

Florida

Association of Florida Community
Farmers' Market
John Matthews
Phone: 941-928-3384

Georgia

Georgia Department of Agriculture
19 Martin Luther King, Jr. Dr., S.W.
Atlanta, GA 30334
Phone: 404-656-3645
Toll Free: 800-282-5852

Indiana

Indiana Farm Market Association
Purdue University
625 Agriculture Mall Drive
West Lafayette, IN 47907-2010

Iowa

Iowa Farmers Market Association
IDALS, Wallace State Office Building
502 E. 9th St.
Des Moines, IA 50319
Phone: 515-281-8232
Barbara.lovitt@iowaagriculture.gov
www.iowaagriculture.gov

Louisiana

Louisiana Farmers Markets
Jimmy Boudreaux, State Farmers
Market Representative
LSU Agricultural Center
155 J.C. Miller Hall
Baton Rouge, LA 70803
Phone: 225-578-2222
Fax: 225-578-0773
jboudreaux@agctr.lsu.edu

Maryland

Maryland Dept of Agriculture
Annapolis, MD 21401
Phone: 410-841-5770
marylandsbest@mda.state.md.us

Massachusetts

The Federation of Massachusetts
Farmers' Markets
240 Beaver Street, Waltham, MA 02452
Phone: 781-893-8222
Fax: 781-893-8777
www.massfarmersmarkets.org

Michigan

Michigan Food & Farming Systems
(MIFFS)
416 Agriculture Hall
East Lansing, MI 48824
Dru Montri, Association Manager
Michigan Farmers Market Association
(MIFMA)
Phone: 517-432-3381
Fax: 517-353-7961
www.miffs.org
www.farmersmarkets.msu.edu

Missouri

Missouri Farmers' Market Association
President Deb Connors, The City Market
20 East 5th Street, St. 201
Kansas City, MO 64106
Phone: 816-842-1271
dconnors@cwbk.com

Nevada

Nevada Certified Farmers Market Association
(NCFMA)
Ann Louhela
P.O. Box 2108
Sparks, NV 89432
Phone: 775-351-2551
markets@nevadagrown.com

New Mexico

New Mexico Farmers' Market Association
320 Aztec Street, Suite B
Santa Fe, NM 87501
Phone: 888-983-4400
dmiller@farmersmarketsnm.org
www.farmersmarketsnm.org

New York

Farmers' Market Federation of New York
Diane Eggert, Executive Director
117 Highbridge Street, Suite U-3
Fayetteville, NY 13066
Phone: 315-637-4690
Fax: 315-637-4691
info@nyfarmersmarket.com

North Dakota

Stephanie Sinner, Marketing Specialist
ND Department of Agriculture
P.O. Box 5316
Fargo, ND 58105-5316
Phone: 701-239-7211
Fax: 701-239-7212
ssinner@nd.gov
www.ndfarmersmarkets.com

Oklahoma

Oklahoma Farmers' Market Alliance
Susie Lawrence
OFMA Secretary/Treasurer
Rt 1 Box 10
Braggs, OK 74423
sandcreekfarm@mynewroads.com
www.okfarmersmarket.org

Oregon

Oregon Farmers' Markets Association
Phone: 541-525-1035
info@oregonfarmersmarkets.org
www.oregonfarmersmarkets.org

Pennsylvania

Farmers Market Alliance of
Western Pennsylvania
1204 Malvern Ave.
Pittsburgh, PA 15217
www.farmersmarketalliance.com

Rhode Island

Farm Fresh Rhode Island
Box 1943
Providence, RI 02912
E-mail: sheri@farmfreshri.org
www.farmfreshri.org

Utah

Richard Sparks, Deputy Director
Marketing and Development Division
Utah Department of Agriculture & Food
Utah's Own Program
350 N. Redwood Road
P.O. Box 146500
Salt Lake City, UT 84114-6500
Phone: 801-538-4913
rsparks@utah.gov

Washington

Washington State Farmers Market
Association
Jackie Aitchison, Executive Director
P.O. Box 445
Suquamish WA 98392
Phone: 206-706-5198
info@wafarmersmarkets.com

West Virginia

West Virginia Farmers Market Association,
c/o Tom McConnell
WVU Extension Service
P.O. Box 6108
Morgantown, WV
26506-6108
TRMcConnell@mail.wvu.edu
www.wvfarmers.org

Wyoming

Wyoming Farmers Marketing Association
Kim Porter
P.O. Box 20939
Cheyenne, WY 82003
Phone: 307-777-6319
www.wyomingfarmersmarkets.org

Farmers' Markets Marketing and Business Guide

By Janet Bachmann
NCAT Agriculture Specialist
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Karen Van Epen, Editor
Amy Smith, Production

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Local Market Wish List 2009

Vegetables

Winter & spring

- Carrots: different sizes, colors, varieties
- Lettuces and greens
- Beets: golden, Chioggia (striped), white
- Cabbage, Savoy & red
- Cauliflowers, Romanesco
- Broccoli, broccoli raab
- Brussels sprouts
- Leeks
- Fennel
- Horseradish
- Potatoes: Russets, storage varieties
- Tomatoes, cucumbers, & peppers – March to June and Nov-December



Spring...

- Asparagus
- Peas – edible pod and shelling
- Celery and celeriac
- Radicchio
- French green bean

Summer

- **Sweet Corn**
- Artichokes
- Garlic
- White and Crimini Mushrooms
- Salad greens, Cilantro (grown at higher elevations)
- Sprouts
- Sweet potatoes
- Sweet & storage onions
- Early small size melons



Fall/Winter greenhouse crops

- Basil
- Cilantro
- Tomatoes
- Cucumbers
- Peppers
- Raspberries
- Flowers



Dried grains & Legumes

- Fresh dried beans, Black-eyed peas
- Pinto beans
- Whole grains and flour
- Rice & wild rice

Herbs

- Chives
- Small bunches of herbs
- Large bunches of basil for pesto



Fruit

- Apples, esp. heirloom varieties
- Table grapes
- Blueberries
- Raspberries, Boysenberries
- Local strawberries
- Sweet cherries
- Sour cherries
- Late mandarins e.g. Tango
- Specialty Figs
- Olives
- Damson Plums
- Pluots
- Certified Organic fruit



Nuts

- Pecans
- Almonds
- Pistachios
- Walnuts
- Black walnuts

Flowers & decorative plants

- Lilacs
- Peonies
- Early spring flowers, late fall flowers
- Chrysanthemums
- Seasonal decorative plant materials



Livestock & Meats

- Eggs
- Free-range chicken
- Free-range turkey

From Joanne's list 1991:

Berries and small fruits

Persian mulberries
Boysenberries
Pie cherries
Bing cherries
Local strawberries, esp. later varieties
Table grapes
Currants
Gooseberries would be nice, but they'd have to come from the North coast

Citrus –probably enough unless we have really late mandarins, Meyers or others
Blood oranges
Lemons
Limes

Vegetables:

Sweet corn
Shallots
Horseradish
Baby lettuce, esp. later in the season

Mesclun mix
Cabbage: Savoy, red, decorative(?)

Purple broccoli

Romanesco broccoli

Specialty cauliflowers

Brussels sprouts

Sugar peas
Pearl onions
Asparagus
French green beans

Asian cucumbers
Lemon grass
Heirloom vegetables (?)
Local artichokes
Hothouse: tomatoes, cucumbers, peppers, herbs
Sprouts (what are EH implications?)
Mushrooms...we need basics!

Other:

Sunflower seeds
Popcorn
Whole grains and flour
Rice, Wild rice
Cider (?EH)

Others that we may or may not need

Poblano peppers
Okra
Specialty melons
Jerusalem artichokes
Baby vegetables
Leeks
Tomatillos
Cilantro (need in summer from higher elevations)
Parsnips

Decorative materials???

Decorative kales & cabbages?
Fall decorations, Indian corn
Decorative gourds
Potted flowering plants - only winter/spring

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Marketing Strategies for Farmers and Ranchers



Creative marketing ideas range from extending farmers market sales through the winter (left) to diversifying from grain into pumpkins (right). The Bolsters of Deep Root Farm in Oregon's Willamette Valley and the Walters in Kansas have both realized new profits. – Market photo by Ted Coonfield; pumpkins by William Rebstock

FOR 23 YEARS, ALL THE MILK FROM JEFF AND JILL BURKHARTS' 80-cow dairy in central Iowa left the farm in a bulk truck for processing and sale in the commodity markets. These days, however, the farm's milk takes a different route to customers. In 2002, the Burkharths decided to build a bottling plant and start selling their milk directly from the farm.

Today, the Burkharths' 80-acre rotationally grazed farm has become a regular destination for customers throughout the Des Moines area, attracting 100 visitors a day and up to 400 when they hold a special event. As the Burkharths had hoped, visitors leave the farm with gallons of fresh, pasteurized milk as well as other products.

"Business is booming," says Jeff Burkhardt, who received a grant from the Sustainable Agriculture Research and Education (SARE) program in 2004 to test two marketing strategies: an open house event and a Website launch. A year to the day after filling

their first milk bottle, the Burkharths premiered their Picket Fence Creamery with an open house that drew more than 900 people for farm tours, children's activities and special sales offers.

The Burkharths have been innovators before. In 1988, they divided their 80-acre grass farm into paddocks, where they rotationally graze 80 Jersey cows moved twice daily to ensure ideal field conditions. Once they started the creamery, they began making butter, cheese curds, and 25 flavors of ice cream. To include other farmers in their venture, they turned the creamery store into a local foods marketplace, featuring everything from eggs, beef, elk and bison, to maple syrup, baked goods, popcorn and wine from 76 other central Iowa families.

"We're taking the raw product, which is the grass, and then adding value to it by feeding it to the cows, then taking the milk and bottling it or processing it into butter, ice cream and cheese," Burkhardt says.

“Our customers really seem to appreciate it – they can see and smell and touch everything, they can watch the processing through the observation window, and they really think that’s neat.”

The Burkharts team up with two other farms nearby – Prairieland Herbs and Northern Prairie Chevre – to share advertising costs and prompt customers to make a day of their farm experience.

Shifting to on-farm sales has been a lot of work, the Burkharts say, but the rewards are many. For one, the couple now earns a good living. Just as important, the new enterprise has fostered family togetherness. “We’re doing this as a family,” Burkhart says. “We get to work together, our kids are here, and we don’t have to commute to work. That means a lot.”

Proactive marketing strategies have proven the key to success for many agricultural enterprises. Rather than accepting the relatively low prices typically offered by wholesalers, direct marketers put the power to turn a profit back in their own hands by capturing a greater share of the consumer dollar. Direct marketing channels offer direct connections to customers, providing them an opportunity to buy fresh products – grass-fed beef, just-picked vegetables, or decorative pumpkins – and knowledge about how they’ve been grown. In return, farmers and ranchers learn what their customers like, then fill those needs with products, often at a premium.

This bulletin from the Sustainable Agriculture Network describes successful direct marketers, most of whom researched their new enterprises with funding from the Sustainable Agriculture Research and Education (SARE) program. It includes tips about how to start or improve a number of alternative agricultural marketing channels

and provides links to extra, more in-depth information. (RESOURCES, p. 20.)

Direct marketing strategies are numerous and varied. Before beginning to sell direct, identify markets with special needs that offer large enough volumes to provide profitable returns. Also consider researching and writing a business plan, which will help you evaluate alternatives, identify new market opportunities, then communicate them to potential business partners and commercial lenders. (See p. 18 and RESOURCES, p. 20.)

Organic foods have held steady as one of the fastest-growing niche markets for several years. More recently, demand for pasture-raised meat and dairy products has risen considerably, with a small but significant subset interested in ethnic specialty meats, such as Halal and kosher-slaughtered products. Buying trends also support a rising interest in food grown and produced locally or regionally, so savvy farmers and ranchers are distinguishing their products by location and quality. Finally, e-commerce has become an established mechanism for sales of all kinds.

Consider selling at farmers markets, opening a CSA operation, developing value-added products, offering on-farm activities like educational tours, selling via the Internet, or marketing to restaurants and schools. You can go it alone, or you can team up with others in a cooperative. Most farmers use a combination of marketing methods – both value-based strategies bringing higher returns and volume-based channels selling more products – finding that diverse marketing strategies provide stable profits and a better quality of life.

FARMERS MARKETS

SINCE 1994, THE NUMBER OF U.S. FARMERS MARKETS HAS MORE than doubled to about 4,000, reflecting an enormous demand for farm-fresh produce.

Most farmers markets offer a reliable, flexible outlet where vendors can sell a wide range of fresh produce, plants, honey, value-added products like jams or breads and even (depending on local health regulations) meats, eggs and cheeses. For beginning direct marketers, farmers markets can be a great place to start. To locate farmers markets in your area, go to www.ams.usda.gov/farmersmarkets/ or call USDA’s Agricultural Marketing Service at (202) 720-8042.

Aaron and Kimberly Bolster have been marketing their fruits and vegetables in Oregon’s Willamette Valley since 1998, gradually expanding Deep Roots Farm from three to more than 100 acres. Their diversified approach to marketing includes a community supported

Jeff and Jill Burkhart opened an on-site creamery to showcase their Iowa dairy products, which they promote through farm days and a new Website developed with help from SARE.

–Photo by Jerry DeWitt



agriculture program, sales to restaurants, local supermarket chains, and even cannery crops. Yet, farmers markets have consistently been among their best outlets.

In 2006, Deep Roots' employees were selling at 12 farmers markets a week during the height of the season. Several are in Portland, a city known for its vibrant and bustling markets that offer everything from heirloom vegetables to bouquets of freshly cut flowers, dry beans, specialty breads, fruit, nuts, beef, lamb and even rabbit.

Asked what makes for a successful farmers market stand, Aaron Bolster emphasizes "the old cliché that you have to have a quality product at a good price. People need to have a reason to come back." Customers develop loyalty to particular farms based on price, quality, the range of offerings, their desire to support local farmers, and the personal connection they feel with you and your farm.

Farmers markets vary widely in size, setting and sales volume. If you're not satisfied with farmers market options in your area, you may be able to improve them by forging alliances with other members of your community. Merchants' associations, chambers of commerce and other civic groups have come to recognize the power of farmers markets to draw customers into retail areas.

Betty King, a University of Kentucky extension specialist for community development, calls farmers markets "America's first grocery stores." King was part of a group eager to emulate the success they saw in the city of Lexington, which enjoys a thriving farmers market with as many as 60 vendors. In neighboring Woodford County, King and other community leaders were eager to encourage a new market in the town of Versailles.

When Versailles' downtown underwent renovation, developers offered to create a covered space where the market could operate year-round. The Woodford County Extension Service built a certified community processing kitchen, and a SARE grant helped fund a training program for farmers interested in developing value-added products to diversify their market offerings. Downtown merchants show their support for the market by purchasing bedding plants and other items from the farmers for seasonal decorations.

The Woodford County Farmers Market now has 10 to 12 vendors selling produce, honey, meat, cheese and freshwater shrimp. "You have to start small and grow the market," King says. "Farmers should realize that they have to invest, too." For example, paying higher stall fees to pay for advertising or a salaried market manager can pay dividends later.



A similar partnership in Santa Rosa County, Fla., spearheaded by a SARE community innovation grant, led to the establishment of Riverwalk Farmers Market in downtown Milton and the creation of a "Santa Rosa Fresh" marketing program to highlight produce grown within the county. Cooking demonstrations with themes like "Cook it Like Your Grandma Did" and "It's Too Darn Hot to Cook" drew record crowds. Other special events featured antique car shows and swing dancing demonstrations.

The county hopes to erect a permanent covered structure for the market on the courthouse square. Another plan is to let high school students earn community service hours to gain eligibility for state college scholarships by working at the market. "It really fits with our mission for the farmers market to have an educational component," says Chris Wilcox of the Santa Rosa Economic Development Council.

Most growers enjoy interacting with other farmers, and many say that cooperation is as important as competition. Expect to have slow days when you do not sell all that you bring, and be prepared to encounter bargain hunters. You may want to investigate gleaning possibilities; many food banks and homeless shelters will pick up extras directly from your stand or farm.

If you're interested in selling at farmers markets, keep in mind:

- 🍷 Successful markets are located in busy, central places and are well-publicized.

Betty King, a Kentucky extension specialist, calls farmers markets "America's first grocery stores." She opened a new market in Versailles, Ky., and provided training for farmers interested in diversifying their offerings.

— Photo by Ted Coonfield

- ☛ Don't deliberately or drastically undersell your fellow farmers. The more farmers and farm products at the market, the more customers.
- ☛ A good market manager promotes the market and enforces its rules.
- ☛ Selling at a farmers market may provide contacts for other channels, such as special orders or subscriptions.
- ☛ Get feedback from your customers. You can learn a lot about what they find desirable – and what to grow next season.
- ☛ For tips on displaying produce, pricing and other practical advice, consult *The New Farmers' Market*. (RESOURCES, p. 20)

COMMUNITY SUPPORTED AGRICULTURE (CSA)

CSA, A MARKETING METHOD IN WHICH MEMBERS OF A community invest in a local farm operation by paying up-front for a share of the harvest, has been growing steadily since it first appeared in the U.S. in the late 1980s. The community idea carries over into the farm itself, with members dividing the weekly harvest as well as the risk of crop failure. Moreover, most CSA farms invite members to learn more about their operations through farm visits, volunteer opportunities and potluck suppers.

No two CSA farms are alike. Most supply produce. They also might provide flowers, berries, nuts, eggs, meat, grain or honey. Farmers may ask members to come to the farm to pick up their shares, or they might

deliver them to centrally located distribution sites. Families run some CSA farms, while others involve groups of producers to supply additional goods. Many CSA farms ask members to commit time and labor to the operation, which not only lowers costs, but also allows members to learn more about what it really means to grow food.

In and around Concord, N.H., eight organic vegetable growers decided to try a cooperative CSA. With a SARE grant, the group worked through the logistics, from the creation of a legal entity called Local Harvest CSA to weekly food production and delivery. Being part of the cooperative makes it possible for the growers to combine what they produce best or substitute for others' crop losses. Co-op members also learn from each other, sharing information about production issues like seed varieties and fencing options. Since forming in 2003, the group has slowly expanded its roster of farmer-members and doubled its number of shareholders to more than 200.

Another model comes from northern California's Full Belly Farm. Run by a team of four farm partners, Full Belly hosts a year-round, 800-member CSA with drop-off sites throughout the San Francisco Bay Area. Full Belly Farm employs 40 workers and grows nearly 80 different types of vegetables, herbs, fruits and nuts as well as flowers, eggs and wool. They also sell at farmers markets and to restaurants.

"I wanted to create a different model than what I grew up with," says Paul Muller, who was raised near San Jose in a family of dairy farmers and now is one of the Full

Full Belly Farm in northern California has cultivated a loyal base of members for its community operation, which provides 80 different types of vegetables and even wool. Paul Muller is one of four farm partners.

– Photo by Neil Michel/Axiom



Belly Farm partners. “On our farm, we have great relationships with our end users – they are the ones we grow for, and they have confidence in our integrity” about how Full Belly Farm produces their food. “They have no question about feeding it to their kids.”

Full Belly Farm has been organic since the 1980s, and hosts an award-winning annual “Hoes Down” festival including kids’ activities, farm tours, food and music. Muller received SARE’s Patrick Madden Sustainable Farmer Award in 2006.

Many CSA farmers produce weekly or biweekly newsletters describing the harvest and providing recipes. Others reach out electronically through listservs or Websites. Full Belly Farm’s Website describes their CSA program in detail – including drop-off locations, prices and payment schedules, a harvest calendar and a newsletter specifying the contents of the weekly CSA box, among other things.

When evaluating CSA as an option for your farm, consider:

- 👉 Your location. Can you find enough members? Can they drive to your farm; or do you need to establish community drop-off sites?
- 👉 Labor. Do you have enough paid support or volunteers to handle the extra jobs involved in CSA, such as packaging?
- 👉 Your willingness to sponsor events on the farm, publish a newsletter and provide other services that help customers feel connected to the farm.

ON-FARM SALES & AGRITOURISM

ON-FARM SALES

JUST LIKE PEOPLE ENJOY WATCHING MILK BOTTLING THROUGH the Burkharts’ observation window (see p. 1), they seek opportunities to shop at farm stands and interact with farmers right where they live. In response, farmers are becoming more attuned to ways they might maximize their offerings. Some pick-your-own operations, for example, have expanded into wedding facilities, farm camps and gourmet specialty stores.

Earnie and Martha Bohner, who started with a pick-your-own operation with no buildings, electricity or running water in 1983, created a Missouri Ozarks destination that now attracts carload after carload of customers, especially in June, July and August, when nearby summer camps are in session.

They began with a long-term plan for Persimmon Hill Berry Farm based on family goals and values. Within 10 years of purchasing 80 acres, they were cultivating 3 acres



of blueberries, 1 acre of blackberries, 2,000 hardwood logs for shiitake mushrooms and 120 apple trees. In addition to the products, they provide amenities: clean restrooms, a picnic table and shade trees – and tidy field edges.

“We create a place where people can enjoy themselves,” Earnie Bohner says. “People don’t come all the way out here to get cheap food. They come because it’s fun and the berries are absolutely fresh. As much as we can, we give them contact with ‘the farmers.’ The more we can do that, the more people go away with that memory.”

An Indiana grower’s use of integrated pest management and shrewd marketing attracted a bevy of new customers to his crop farm. In 1992, Brian Churchill began using integrated pest management on some of Countryside Farm’s 100 acres of sweet corn, melons, tomatoes and other produce. In 1994, with a SARE producer grant, Churchill began scouting for pests, withholding routine spraying and building better habitat for beneficial insects. He cut insecticide costs drastically, then decided to use that as a marketing hook.

First, Churchill attracted the attention of local chefs with an “expo” (see p. 13). He also opened a thriving roadside stand, where the corn is the big seller.

“We drive the point home about using less chemicals all the time,” he said. “I have been growing sweet corn now for 16 years and the customers keep coming back and bringing friends with them. It’s been great.”

Once he perfected his system, he expanded into watermelons, pumpkins and squash and began inviting school children to visit to learn more about farming, judicious agri-chemical use and pollination. In 2005, 1,500 students visited the farm. “Our farm has grown a lot since the grant,” he says.

Marlene Groves and husband, David, provide tours of their 2,000-acre Kiowa, Colo., buffalo ranch to promote a better understanding of agriculture, ecology and nutrition.

– Photo courtesy Buffalo Groves



The Walters' 100 varieties of pumpkins and squash attract 15,000 visitors every fall. The new enterprise has brought their daughter's family back to the Burns, Kan., farm.

– Photo by William Rebstock

In the Pacific Northwest, Larry Thompson grows 43 fruit and vegetable crops on 140 acres in Boring, Ore. Once he decided to convert his parents' farm from wholesale produce and flung open the farm gate to the suburban Portland community, his neighbors began coming and haven't stopped.

Many call Thompson a pro at "relationship" marketing, forming bonds with customers who see a value in local produce raised with few chemicals. Each year, thousands of students – as well as other farmers and researchers – visit his farm to learn about his holistic pest management strategies and view his bounty of colorful crops.

AGRITOURISM

POTENTIAL AGRITOURISM ENTERPRISES ABOUND. FIGURE OUT what's unique about your farm and your skills, and use those things to create an enjoyable, educational experience that will appeal to your customers. The key to agritourism is authenticity and creativity.

Becky Walters planted her first acre of pumpkins on her central Kansas farm in 1988 after her boss at a local greenhouse gave her seed for a new miniature pumpkin that was popular at nurseries and farm markets.

"My husband caught a big razzing at the co-op," she recalls, "but I made \$583 selling them, twice what we would have made on the 5 acres of milo we usually had in that field."

Like most of their neighbors, Becky and her husband, Carroll, had been growing milo and soybeans and grazing cattle for the commodity market. With grain and beef prices hovering at or below the cost of production, the couple was eager to find a way to

breathe new profits into the 1,700-acre farm where Carroll had grown up.

Bit by bit, the Walters expanded that original acre of pumpkins to 16 acres. They built a processing kitchen so they could create value-added products. Then they added a gift shop, a swinging bridge over their creek to appeal to kids, a corn maze and educational tours to draw customers to their farm, ideally located for a tourism venture just minutes off the Kansas Turnpike.

Today, the Walters grow more than 100 varieties of pumpkins, gourds and winter squash – from minis to giants – along with tomatoes, peppers and onions. Planting many squash varieties also helps the Walters spread risk, since different types thrive in different weather conditions. Drawn by the variety and convenient location, as many as 15,000 visitors flock to Walters' Pumpkin Patch in the six weeks leading up to Halloween.

"People come just to see all the different kinds that we have," says Becky Walters, who received a SARE farmer/rancher grant to experiment with ways to add value to pumpkins by making salsa. The product, after experimentation with the recipe and the right jar for packing, dovetails with their tourism efforts, complements their other vegetables and provides new jobs in their community.

The enterprise has been so successful that her daughter and son-in-law have moved back to the farm to help out. With their two young grandsons beginning to get involved in the business, Becky says, "it feels like a real family farm again."

To expand their educational efforts for school groups, the Walters will teach visitors about native frogs and fish in their farm pond and incorporate information about the Walnut River, which surrounds them on three sides.

"I think having an idea of doing something and jumping off the cliff to do it is the hardest part," Walters says. "Sometimes it takes what I call 'thinking outside the barn.' When you put a pencil to it, it just doesn't make sense for us to grow the conventional crops any more."

The Walters and others who offer educational programs for school groups recognize that teaching children usually requires special skills and always a good set of ideas. To engage children, consider getting them involved in projects – whether it's digging potatoes, planting corn, or decorating pumpkins. Keeping groups small helps. Of course, ensuring safety is paramount, especially on farms with heavy equipment and other hazards. If you don't have the resources to develop educational programs on your own, consider working with local schoolteachers, FFA groups, or others in the community.

Marlene Groves of Buffalo Groves, Inc., in Kiowa, Colo., developed youth education programs – including an “American Buffalo” Girl Scout patch program and an educational youth buffalo project for 4-H – to teach about buffalo history. The ranch’s “Bison Reader,” a youth activity sheet, is a favorite at many schools and nature centers. Efforts like these, Groves says, foster a better understanding of ecology, agriculture and nutrition. Mainly, she wants kids to know where their food comes from.

The Groves teach people, young and old, about their ranch and their niche product during ranch tours. They charge \$25 per person, refundable in the form of store credit, and also offer customized tours for private events.

“It takes work to run tours” on a 2,000-acre ranch, Groves acknowledges, “but we want to showcase what we’re doing.” They lead visitors on walks, talk about grazing management and point out native grasses and wildflowers. “Of course, the highlight is going out to see the buffalo herd,” she says.

Offering tours is a way of taking advantage of consumers’ and the media’s interest in farm life, Groves says. As part of that, “tell a good story – tell your own story,” she advises. In addition to selling meat on the ranch, they also market and deliver directly to customers in Denver and Colorado Springs and from their Website.

Other ranchers have expanded into diverse on-site activities, offering hunting, fishing, bird-watching, horseback riding or hiking. In Colorado, co-owners of the 87,000-acre Chico Basin Ranch began offering working ranch vacation packages in 2000. While it’s taking time to make that side of the business fully profitable, they feel they’re moving in the right direction, says ranch manager Duke Phillips.

While some people visit just for birding, which brings lower returns, “we have packages where people stay for a week and we get paid well for that,” says Phillips. “We have to balance what we do with our values, the reason we’re here as ranchers.”

Chico Basin was among a group of ranches in Colorado, Wyoming and other western states that benefited from a SARE grant exploring various types of community-based direct marketing models for ranch owners seeking to diversify. The key is to put a value on the natural resource amenities provided by ranchlands and to find ways for urban- and suburban-based consumers to enjoy those amenities.

COMMUNITY-BASED FARM TOURISM

FARMERS CONSIDERING WAYS TO PUT THEMSELVES ON THE MAP, literally, might team up with state or regional agencies

to promote rural economic development through farm-based tourism activities. In many parts of the United States – not just traditional vacation destinations like Hawaii or New England – tourism can make a significant contribution to local economies, and attractive, well-managed farm operations can do a lot to draw rural tourists. Explore local government, quasi-government and business connections to participate in local festivals, get listed in state tourism brochures or be featured in regional public outreach campaigns.

In Minnesota, the nonprofit Renewing the Countryside organization used a SARE grant to promote local food-based tourism. Working with groups like the Minnesota Bed & Breakfast Association and the University of Minnesota Tourism Center, RTC developed a promotional campaign called Green Routes. Printed maps and an online directory (www.greenroutes.org) guide visitors to farmstands, craft shops and other rural destinations. “There’s a lot of interest in and support for ‘green’ travel, and farmers are a big piece of that,” says RTC’s Jan Joannides.

Similar efforts are underway in Rhode Island, where the Rhode Island Center for Agricultural Promotion and Education launched “Rhode Island FarmWays,” a campaign to highlight farms as tourist destinations. The goal, says Center Executive Director Stuart Nunnery, is “to help showcase Rhode Island’s farms as places of significant beauty, culture, ecology and history. Those farms are crucial to maintaining Rhode Island’s quality of life.”

With help from a 2004 SARE grant, Nunnery and colleagues have held professional development workshops for farmers, provided grants to help producers initiate farm-based tourism activities and created a

Hidden Meadows Farm in West Greenwich, R.I., a member of the state FarmWays agritourism campaign, hosted the public during a Thanksgiving weekend of on-farm activities. The farm sells Christmas trees and value-added products.

– Photo by Jo-Anne Pacheco



Nutritional tests on meat from Buffalo Groves in Colorado found the cuts were significantly lower in calories and cholesterol than grain-fed bison meat, providing a marketing angle for David and Marlene Groves.

– Photo courtesy of Buffalo Groves

Website listing farm-based attractions statewide. The Rhode Island Center also negotiated a \$250,000 loan package with the state Economic Development Corp. to provide small loans to farmers to develop or expand agritourism and direct marketing activities. Finally, the team is focusing on streamlining the regulatory process by which farmers can set up farm stay or bed & breakfast operations.

“Our farms have a variety of untapped assets that can create products and experiences for visitors,” says Nunnery. “They could be walking trails, historical features, wildlife, heritage livestock, horticultural diversity or just a spectacular landscape. We have farms with beautiful grasslands preserved by conservation easements. One of the farms we’re working with has ancient settlements and artifacts being excavated by university archaeologists.”

If you’re interested in on-farm sales and agritourism, consider the following.

- Check your local extension office for information about how to construct sales stands, small market buildings and produce displays. From building materials to permits, establishing a stand can prove expensive.
- Social skills and a scenic, clean, attractive farm are crucial for success in agritourism and can overcome a location that is less than ideal.
- Farm visitors may interfere with main farm activities and pose a liability risk. Consult your insurance adviser to ensure adequate liability coverage.
- In the tourist business, you are never really off-duty. Expect late-night calls and working holidays.
- State departments of agriculture often offer assistance in setting up farm festivals and similar activities. State tourism bureaus also can offer a wealth of ideas and information.

DIRECT MARKETING MEAT AND ANIMAL PRODUCTS

AFTER YEARS OF WATCHING FEED PRICES RISE AND PORK prices fall and wondering how they could stay profitable, Denise and Bill Brownlee of Wil-Den Family Farms in Pennsylvania decided in 2002 to exploit what they saw as a market advantage – their outdoor production system where hogs farrow and finish on pasture without growth stimulants and with minimal antibiotic use.

Given the time commitment involved in direct marketing, the Brownlees started by scaling back from 170 sows to 60, aiming to sell 900 to 1,000



animals a year at a premium price. Over the past several years they’ve explored a variety of direct marketing strategies. A SARE grant enabled them to partner with a local nonprofit group to test a subscription service for meat, in which up to 100 members would purchase annual shares of pork chops, sausages, bacon and ham.

What they found was that customers were more comfortable with monthly meat subscriptions than with annual meat shares. “We tried to pattern it after how people are used to buying from vegetable farmers: paying upfront,” Denise Brownlee says. “For whatever reason, they were hesitant to commit.” Their experience shows that translating marketing strategies from one type of product to another can require some tweaking.

Decades ago, most meat and animal products were sold directly to customers, but all that changed with the advent of the modern feedlot-to-wholesale system. Recently, consumer concerns about nutritional health, food safety and animal welfare have spurred renewed interest in buying animal products directly from the source. Producers, meanwhile, see the value of re-connecting to consumers.

Making the most of your direct marketing efforts requires being able to explain to customers why your product is better than what they can find in their local supermarket. To make specific nutritional claims for

your product, consider getting samples tested by an independent lab. With a SARE producer grant, David and Marlene Groves tested their 100-percent grass-fed bison meat, which they sell directly from their Colorado ranch. They learned that the meat was slightly lower in fat and significantly lower in calories and cholesterol than the standard published values for bison meat.

“It’s very hard to confidently market your product if you don’t completely understand it,” Groves says. “Most buffalo for sale in the supermarket is grain-fed, and it’s much fattier.” Once customers understand the difference, they often are more inclined to buy Buffalo Groves meat.

Another expanding market opportunity for sustainable livestock producers centers on health. Health care practitioners and individuals seeking to improve their diets in response to concerns about chronic disease, pain syndromes and various disorders are fueling demand for better quality meat. The University of North Carolina Program on Integrative Medicine used a SARE grant to compile a directory of locally raised, grass-fed livestock products after receiving repeated requests for such information from holistic health care providers in the area. Part of their research included sources of meat with desired levels of omega-3 fatty acids.

For livestock producers facing an increasingly concentrated market with a few large processors controlling prices, direct marketing offers the opportunity to retain a greater share of product value. Marketing meat and animal products, however, means making food safety issues paramount. (See box at right.)

Provide cooking instructions, especially for grass-fed meats, which require lower cooking temperatures than conventionally produced meat – “low and slow,” as Texas rancher Peggy Sechrist likes to describe it. If possible, provide samples. With a quality product, sampling can be the most effective form of marketing.

Jim Goodman of Wonewoc, Wis., began direct-marketing organic beef not only to increase profits, but also to talk with and educate his customers about sustainable beef production. After 16 years of selling to packing companies, Goodman now delivers beef to restaurants, a farmers market and directly to friends and neighbors. Customers are getting used to ordering by e-mail in the winter, so direct marketing continues during the winter through scheduled deliveries.

“Traditionally, farmers never see their customers,” says Goodman, who regularly drives 75 miles to Madison to deliver beef. “It’s nice to be able to hand your customers a package of burgers with tips on how to cook it and be

able to tell them how the animals are raised.”

When he takes a 1,500-pound steer to the packing plant, he receives about \$1,000. That same animal brings \$2,500 minus about \$450 in processing costs, when he sells it directly.

“People are willing to pay more for direct-marketed organic beef,” he says. “Once you get regular customers, you develop a friendship with them. Then people start talking about buying meat from ‘my farmer.’ It really is the way marketing should be done, the farmer delivers a quality product, and the consumer is happy to pay them a fair price, everyone wins.”

Cooperatives provide another route for direct marketing meat. In 2001, a group of Iowa livestock producers launched Wholesome Harvest, a cooperative featuring organic meat sales in five Midwest states. Co-op founder Wende Elliott, who raises lamb and poultry, got a grant from SARE to research the potential – since realized with steady sales. “Only by working together can farmers protect the added value of organic meat and capture premium prices,” Elliott says. (See p. 15 for more information on co-ops.)

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ANIMAL PRODUCT LABELING & CLAIMS

Meat producers address consumer safety concerns through regulatory avenues as well as processing and inspection. Before launching a direct meat-selling venture, decide where and how you want to market. The type of processing and inspection you choose limits where the meat can be sold, dictating whether you can sell across state lines and whether direct to consumers or wholesale.

For more information about meat inspection and overall marketing regulations, see the *Legal Guide for Direct Farm Marketing*, developed in part with a SARE grant. To learn more about direct-marketing beef, from slaughtering to promoting and advertising, consult *How to Direct Market Your Beef*, published by SARE’s Sustainable Agriculture Network. (RESOURCES, p. 20.)

You may want to develop labels describing how you produce your meat, specifying your feeding, medication and other practices and/or where you farm or ranch. Check with USDA’s Food Safety Inspection Service (FSIS) at www.fsis.usda.gov, (202) 205-0623 and the USDA Agricultural Marketing Service’s Livestock and Seed Program, www.ams.usda.gov/lsg, to create accurate, legal claims.

For organic labels, see USDA’s National Organic Program Website – www.ams.usda.gov/nop – or call (202) 690-0725 with questions. For regulations and information related to food safety in livestock products other than meat and eggs, such as milk pasteurization, visit the Food & Drug Agency’s Center for Food Safety and Applied Nutrition at www.cfsan.fda.gov.

To better address the needs of the small business community, including farmers and ranchers, FDA assigned its small business representatives (SBRs) to respond to questions such as how to find the FDA regulation(s) pertinent to your product. To find the SBR nearest you, visit www.fda.gov/ora/fed_state/Small_Business/sb_guide/smbusrep.html.

PROMOTING MEAT TO ETHNIC MARKETS

To expand sales of their lamb and goat meat, Larry Jacoby and Judy Moses built new connections with the growing populations of Mexican and Somali immigrants in western Wisconsin. Their efforts – advertising in multiple languages, promoting visits to their 140-acre farm in Downing, Wis., and attending customer weddings, among them – have resulted in a substantial increase in annual sales.

“We like working with a variety of people, it fits our interests intellectually,” said Judy Moses, who, with husband Jacoby, received a SARE farmer/rancher grant to explore new ways to promote to culturally diverse customers. “Once you get into their network, you’re in. When we have goats for sale, the word spreads quickly and customers come.”

Now, they sell almost all of their goats and about 40 percent of their lambs to ethnic customers at premium prices. In busy periods during the Muslim month of Ramadan, Christmas and New Year’s holidays, monthly sales of adult goats, kids, and 80-pound lambs surge.

In 2005, they sold more than 500 live goats and lambs during the holidays at an average of \$100 each.

Moses and Jacoby learned a lot over the two years of their grant project about how to reach new customers, many of whom speak limited English, come to the farm at all hours, and want to slaughter their animals according to religious customs.

Moses’ co-worker at her off-farm job, a Somali native, sparked the project by suggesting that local Somalis, many of whom work at a Barron, Wis., turkey processing plant, craved fresh goat meat. While Moses and Jacoby tried ads in ethnic magazines, established a multi-lingual Website and posted information on bulletin boards and tourist information centers, word-of-mouth brought the most customers.

A friend who worked at the processing plant encouraged some of her Somali co-workers to visit Moses’ and Jacoby’s



Shepherd Song Farm, where they raise about 400 goats and 300 lambs annually on pasture.

In keeping with tradition, the Somalis wanted Halal slaughtering practices involving a Muslim imam. Moses found a state-inspected processor 14 miles away willing to slaughter goats in the preferred manner with the local imam present to supervise. Moses and Jacoby adapted in other ways, too, growing accustomed to unannounced visits from families, some of whom liked to pick up

animals in the midst of the winter holidays. Many of those visitors bought 10 to 20 goats at one time. They even bartered occasionally, with Jacoby swapping lamb for a new pair of leather boots imported from Mexico, among other items. Customer relations soared.

“Mexican and Somali families have sought us out,” Moses said. “These families purchase something more than food – a memory of their heritage while strengthening family bonds.”

SEASON EXTENSION

WHETHER YOU’RE SELLING AT FARMERS MARKETS, THROUGH a CSA or on your farm, lengthening your marketing season can be critical to spreading your workload and evening out your cash flow. It can also help maintain relationships with customers and allow you to offer year-round employment to key employees. While some farmers enjoy having off-season “down time” to make repairs or plan for the coming year, others find that practicing seasonal diversification makes for a more well-rounded farm enterprise.

Season extension involves using greenhouses, unheated hoop houses, row covers or alternate varieties to push fruit and vegetable crops earlier into the spring or later into the fall.

In Oregon, farmers Aaron Bolster of Deep Roots Farm and Anthony and Carol Boutard of Ayers Creek Farm teamed up with the Oregon Farmers’ Market Association on a SARE-funded project to test the idea of extending a popular Portland farmers market through the winter

months. Customers got acquainted with the wide array of local products available year-round, while farmers gauged off-season demand. Deep Roots used hoop houses to grow late-season greens and other cold-hardy crops; other farmers, like the Boutards, offered value-added products based on their summer berries and other specialties.

“This is an area where there used to be a lot more emphasis on winter production, but with more shipping and competition from the South, it kind of fell away,” Bolster says. “Now, with the demand for local produce, there’s a real opportunity for farmers who are willing to take it.”

A key goal for Bolster and the Boutards was to keep people employed year-round to foster good workers. They also found the winter market was a catalyst for them to grow more vegetables year-round, then try shopping any extra product to local stores and restaurants. “In winter there’s certainly more risk, but it’s worth it,” Bolster says.

Sometimes, the key to capturing a valuable market is timing. Having the earliest local sweet corn or tomatoes

at the farmers market will command a price premium; the trick is to keep customers coming to your stand through tomato season and beyond. Thinking creatively about how to maximize the overlap between peak demand and peak production is an important part of direct marketing. Becky Walters of Burns, Kan., developed her distinctive pumpkin salsa after selecting an early-maturing pumpkin variety to coincide with tomato and pepper season.

Another part of season extension has to do with understanding the seasonal preferences of your target market. Meat producers often find that customers buy ground beef in the summer and roasts in the winter, for example. In Colorado, the Groves have learned that they have to ship on Thursdays because many people like to receive their meat on Friday for special weekend meals. Moreover, the Groves say that bison sales are strong around the winter holidays and into January, apparently because people resolve to eat healthier meats around the first of year. Finally, raising heritage turkeys for the Thanksgiving market has proven a yearly boon for many poultry producers.

VALUE-ADDED PRODUCTS

IN 1986, EARNIE AND MARTHA BOHNER BEGAN MAKING JAM IN rented facilities near their farm in southern Missouri. Since then, Persimmon Hill Berry Farm has built a processing kitchen to make value-added products, from jams to sauces. To create specialty items that would appeal to customers, the Bohners did their homework. First, they worked with a chef to perfect recipes for jams and barbecue sauce. Later, with a SARE grant, they sought ways to

add value to shiitake mushrooms. After market research, including detailed cost comparisons, showed that freeze-drying on site would be prohibitively expensive, the Bohners decided to dry their fresh shiitakes off-site, then convert the high-value product into a top-shelf shiitake soup mix.

“The development of new products is something we work at all of the time,” says Earnie Bohner. “New farm products and enterprises help keep us interesting to our return guests and give our first-time guests more motivation to come and see us.” Today, their sales of value-added products accounts for 50 percent of the farm’s gross income.

Processing fruits and shiitake mushrooms allows the Bohners to use “seconds,” extend their marketing season and diversify their marketing outlets.

Dan and Jeanne Carver diversified their central Oregon ranch by developing a variety of value-added products from their sheep flock. With a SARE farmer/rancher grant, Jeanne Carver tested the market, then targeted lamb and wool sales toward high-end consumers and commercial buyers. Now, they sell Imperial Stock Ranch lamb to upscale restaurants in Bend, Ore., wool in yarn-and-pattern kits for hand knitters, and ready-to-wear woolen and lambskin fashions.

“Our customers love the quality of our product, the flavor profile of the meat, the feel of the wool, and the message of the land and sense of place,” Carver says.

Direct-marketing their lamb led to selling some of their main product – beef – directly as well. “The marketing project has increased awareness and visibility of



Greenhouses and high tunnels – unheated, pipe-framed structures – offer options for producing before and after the traditional season. Easy-to-construct tunnels have been especially popular for off-season fruits and vegetables that fetch premium prices.

– Tunnel photo by Mark Davis; greenhouse photo by MB Miller.

left to right

To add value to local fare, the Northeast Organic Farming Association of Vermont developed pizza on-the-go featuring a portable oven and diverse products, from wheat to vegetables to meat. Lisa Harris of NOFA-VT demonstrates.

– Photo by Lindsey Ketchel



Sheep rancher Jeanne Carver developed a line of woolen garments such as fleece vests featuring their Oregon-raised wool, adding value to a typically low-priced commodity.

– Photo courtesy Imperial Stock Ranch



what we grow, how we grow it and, most importantly, how we manage the land,” says Dan Carver. “Once the chefs [buying Imperial Stock Ranch lamb] tour the ranch and see the roots of their product, they ask “How do we get your beef?” The demand is there,” he notes, “but it will grow only as fast as our processing and distribution will allow.”

In the Northeast, where festivals proliferate, the Northeast Organic Farming Association of Vermont (NOFA-VT) used a SARE grant to research a variety of prepared foods for sale at fairs, festivals and farmers markets. Their goal was to develop a healthy value-added product that featured diverse local ingredients purchased directly from farmers and appealed to festival-goers. The answer turned out to be pizza.

To make it work, NOFA-VT needed a portable oven. They contracted with a Maine company that specializes in wood heating to build them a wood-fired French clay, copper-clad oven, with help from a USDA Rural Business Enterprise Grant. They then set it on a trailer so it could be pulled from event to event by truck. In 2006, “Vermont Farmers’ Fare” began selling 12-inch pizzas made from Vermont-grown wheat, vegetables, cheese and meat.

The pizzas “are a big hit!” says Enid Wonnacott, NOFA-VT’s executive director. “No one can believe the crust is made, partially, from local wheat. One of our goals was to get local food on the radar screen of people who may not even think about the farms in their community and what is available from those farms.”

Wonnacott and others planned the portable pizza project to offer farmers a direct market benefit, and also to encourage them to sell their own value-added

products. The oven also cooks bread, pies and even roasted vegetables.

Value-added opportunities are everywhere. Examine your product and brainstorm about how processing might increase its value. Fruit growers can dry their product or make wines, juices, vinegars, spreads, sauces, syrups and preserves. Grain growers might create cereals and baking mixes. Dairy operators can bottle milk or make cheese, while livestock producers might sell dried meat or specialty cuts.

When you add variety to your product line, you increase the choices presented to your customers and your chances for expanding your sales volume.

Some things to keep in mind when contemplating value-added products:

- Consider projected costs and returns carefully before investing in specialized equipment for value-added products. Often it makes sense to work with a co-processor to test your market.
- Some of the best value-added items make use of by-products or seconds.
- Seek the experts. Consult with your state Extension Service, Department of Agriculture or small business groups about packaging, processing and recipe development.

SALES TO RESTAURANTS & INSTITUTIONS

RESTAURANTS, ESPECIALLY HIGH-END RESTAURANTS, PROVIDE lucrative markets. Chefs and restaurant patrons pay premium prices for top-quality, distinctive, locally grown products – if they are available in quantities that warrant inclusion on the menu. Some states and regions have created marketing programs to encourage restaurants to feature local farm products, and an increasing number of restaurants identify farms in their menu item descriptions and in other promotions.

The challenge often lies in getting farmer-chef relationships established. In some areas, organized sampling events have brought farmers and chefs together to talk about seasonal availability, preferred crops and varieties, volume, post-harvest handling and delivery logistics.

In the mid-90s, after receiving a SARE farmer grant, Brian Churchill held an “expo” for 50 chefs from top restaurants in nearby Louisville, Ky. “We showed we can produce the volumes they need in as good or better a quality as they can get anywhere,” Churchill says.

The SARE grant started Churchill down a path he continues to tread more than a decade later. He expanded his “IPM sweet corn” to 60 acres and sells that and other produce to two chefs, who pick up their requests at the farm twice a month.

Another SARE-funded project in northwestern Arkansas organized 11 “All-Ozark Meals” at restaurants, delis, farmers markets and other locations in 2003. Enthusiasm from the event translated to more local purchasing by restaurants and groceries and a new commitment from a regional environmental group to support farmland preservation issues. Several chefs who cooked for the All-Ozark Meals now participate in a popular competition at the Fayetteville Farmers Market, in which chefs have two hours to shop at the market and then prepare a three-course meal using all-local ingredients. Strong media response has confirmed the value of farmers’ stories when it comes to selling food.

In Hawaii, a SARE-funded effort known as the “12 Trees” project is combining new crop development with culinary expertise, organic growing techniques and agritourism. Farmer and organizer Ken Love solicited input from chefs to identify 12 tropical tree fruits with commercial potential. Then, project leaders and volunteers planted trees on a demonstration site where farmers and researchers could learn about production methods – and tourists and local residents could come to see, taste and buy unusual fruits. Over the course of the project, it evolved from a research plot to a tourist destination.

“This came about solely because of community involvement,” Love says. “So instead of a university test plot, we have an attractive public park complete with educational displays on sustainable agriculture.”

As the trees come into full production, the Kona Pacific Farmers Cooperative will market the fruit to area restaurants. Students at the West Hawaii Culinary Arts program have been involved in developing recipes for

the fruits, which include loquat, pomegranate, mysore berry, tropical apricot, figs and more.

“Everyone wins and benefits from this project,” Love says. “Researchers have a sustainable certified organic field for tropical fruit production tests, and chefs and student chefs are exposed to a wide variety of fruit that they continue to purchase from local growers.”

The 12 Trees site, located near the culinary school, was designed for visitors. Self-guided tours with field signs highlight information for growers and consumers. Two natural amphitheatres provide space for local groups to hold on-site workshops on such subjects as pruning and grafting. It also draws visitors to the 101-year-old historic Kona coffee co-op.

Other farmers report success from approaching local chefs directly.

“It seems that every type of restaurant has its own particular needs,” writes Jan Holder in her book,



top to bottom

Rare Hawaiian striped bananas are among the local fruits with a “wow” factor grown at the 12 Trees demonstration site in Kona and are a potentially hot crop for area chefs.

– Photo by Ken Love



Upscale restaurants like Restaurant Nora in Washington, D.C., feature ingredients procured from local farmers as a hook to draw customers.

– Photo by Edwin Remsberg



How to Direct Market Your Beef (RESOURCES, p. 20), adding that locally owned restaurants are a much better bet than franchises. “Restaurateurs usually want fresh, not frozen beef. They also want a uniform product. The last thing a restaurant manager wants is a customer complaining that last time he ordered this steak it was a lot bigger, or leaner, or more tender, or whatever.”

Restaurants already working with seasonal, locally produced foods might be most willing to work with you, Holder says. Providing weekly availability lists can help educate chefs and other food service personnel about their options.

Prospective restaurant suppliers should consider:

- 👉 Upscale restaurants and specialty stores pay top dollar for quality produce and hard-to-get items. According to Eric Gibson’s *Sell What You Sow!*, growers can expect a minimum of 10 percent over wholesale terminal prices for standard items at mainstream restaurants.
- 👉 Most restaurants buy in limited quantities, and sales may not justify the necessary frequent deliveries. Growers should line up buyers a year in advance and develop secondary outlets.
- 👉 Call buyers for appointments and bring samples.
- 👉 Meat producers can offer a variety of cuts, and even bones for soup stock, but most restaurants will want fresh products.
- 👉 Major selling points include daily deliveries, special varieties, freshness, personal attention and a brochure describing your farm and products.
- 👉 When planning your crop mix, talk with chefs and specialty buyers, who are constantly looking for something new. Successful restaurant sales depend

on meeting the changing needs of your buyers.

Other farmers and nonprofit organizers are exploring the potential of direct farm sales to institutions like schools, hospitals, and senior-care facilities. Philadelphia’s nonprofit Food Trust received a SARE grant in 2003 to strengthen farmer access to markets in the inner city. Working with farmer groups, extension services and institutional buyers, the group brokered marketing relationships, matching farmers with buyers, bargaining for better prices and coordinating deliveries.

Among the project’s successes was the creation of a “Farm Fresh” fruits and vegetable option for people participating in a “share food” program run by a state nonprofit organization. That program offers discounted monthly food packages with a labor commitment. About one-quarter of participants now choose fresh produce that was not previously available.

Sales from farms to Philadelphia schools is set to top \$200,000 in the first two years of the group’s farm-to-school project, according to Food Trust staffer Patrick Gorman. A special kindergarten initiative is supplying Pennsylvania farm produce for morning snacks at 11 schools, three days a week. The project has nutritional and educational benefits for the children as well as economic benefits for the farmers.

Selling to schools can be challenging – budgets are limited, many decision-makers are involved, and many schools no longer manage their own kitchens. But as public concern over childhood obesity grows, new opportunities for school food programs are opening in many parts of the country. Privately run schools and institutions often have more flexibility than public schools.

left to right

Philadelphia’s nonprofit Food Trust created linkages between Pennsylvania farmers and city schools, such as farm visits. A kindergarten student visits Solly Brothers farm in Bucks County, Pa., with his class.

Among the sales of locally produced food brokered by The Food Trust: a special morning snack for kindergarteners.

– Photos by Bonnie Hallam



COOPERATIVE MARKETING/CAMPAIGNS

SOME DIRECT MARKETERS GO IT ALONE, BUT MANY FIND THAT teaming up with others shares skills and abilities, moderates the workload and minimizes hassles.

After Terry and LaRhea Pepper's single buyer reneged on a contract to buy their entire crop of organic cotton near O'Donnell, Texas, they found themselves with bales of raw cotton and no buyer. Scrambling for an alternative, the Peppers decided to try converting the raw product into denim. LaRhea Pepper, who had majored in fashion merchandising in college, contacted companies interested in finished fabrics and secured a new buyer.

"We realized, then and there, that security and profitability depended on our assuming responsibility for processing and marketing our cotton," La Rhea Pepper says. "We don't rely on anyone else."

The Peppers joined forces with other organic and transitional cotton growers to form the Texas Organic Cotton Marketing Cooperative. Through the co-op, they shared marketing expenses and risks, then dealt with buyers as a team.

"We were realistic," LaRhea Pepper says. "We realized we couldn't deliver a consistent supply as the only producer."

When the cooperative was formed in 1991, it brought together 40 farm families who sought to market their organic and transitional cotton. The cotton co-op sells raw, baled cotton or an array of processed products such as personal hygiene aids and a diversity of fabrics through their Website.

As more members of the co-op were drawn into marketing decisions, they also saw the need to create new products, expand markets and promote themselves. They diversified the product line to include chambray, flannel, twill and knits. Lower grade, shorter staple cotton, not suited to clothing, is used to make blankets and throws. Most recently, an "Organic Essentials" division was created to manufacture facial pads, cotton balls and tampons. The co-op board continues to look for other opportunities to add value to their cotton, and for partners in the industry who are willing to share the cost and risk.

The benefits of marketing agricultural products with others also appealed to Janie Burns of Nampa, Idaho, who raises sheep, chickens and assorted vegetables on 10 acres. A relatively small farmer, she is a large-scale promoter of local food systems. With a SARE grant, Burns investigated whether a growers' cooperative would help area farmers become more efficient and profitable, while offering their community access to

fresh, sustainably grown vegetables.

"We went to every list of people involved in direct marketing," Burns recalls. They surveyed 150 people within the Boise/Twin Falls area, which shares a similar climate and crops, about their interest and capabilities. Then, they identified markets, such as restaurants, natural food stores, a cafeteria, a hospital and a school.

The Boise-area farmers agreed to form their own co-op under the name Idaho Organics Cooperative, Inc. Now, the group has it down to a science. Every Sunday, co-op growers send lists of what they will have for delivery that week, including quantity, description and price, via fax, to their customers. Based on responses, the farmers harvest, then pool produce at a central location for boxing and delivery.

In Tennessee, in a similar venture with a value-adding twist, farmers who wanted to convert their harvest into high-value products formed a marketing cooperative called Appalachian Spring. With a SARE grant, Steve Hodges and the Jubilee Project investigated the feasibility of using a community kitchen in the nearby town of Treadway, then co-marketing their products – a variety of salsas, fruit spreads and personal care goods. Once they crunched the numbers and saw a positive prognosis, they began selling the items through the co-op's Website as well as through retail locations such as a regional airport gift shop.

The group also sells seasonal gift baskets to area church groups, a terrific way to highlight local products. "We tried wholesaling at first," Hodges says, "but we found that small processors just can't compete against big companies, even with a co-op." In addition to joint marketing, co-op membership offers other benefits, like sharing equipment and bulk ordering supplies.

Cooperative marketing can be a great opportunity – or a headache. Here are some tips on how to make it work for you:

- 👉 The USDA Rural Development Business & Cooperative program offers information and assistance in setting up and managing a cooperative marketing effort. It's a great place to start (RESOURCES, p. 20).
- 👉 Consider a marketing club, an informal cooperative that relies on using member marketing skills. Many extension offices offer training programs and assistance in setting up marketing clubs.
- 👉 Join a nonprofit farmer network group to share ideas and inspiration.
- 👉 Adequate market research and business planning are keys to successful cooperative marketing.

In Tennessee, farmers who wanted to convert their harvest into high-value products formed a marketing cooperative called Appalachian Spring. With a SARE grant, they opened a community kitchen.

left to right

The Mountain Tailgate Market Association unites a number of small farmers markets representing 150 small farms in western North Carolina, funding a multi-media promotional campaign, among other ventures.

— Photo by Charlie Jackson

Buy Fresh, Buy Local campaigns sponsored by Food Routes (www.foodroutes.org) boost sales of local products across the United States.



BUY LOCAL CAMPAIGNS

PUBLIC CAMPAIGNS CAN ENGAGE CONSUMERS AND PROMOTE purchases from farmers and ranchers. In 2003, California vegetable grower MaryAnn Vasconcellos approached the Central Coast Resource Conservation & Development Council (RC&D) with the idea of launching a campaign informing consumers why and where to buy local. Vasconcellos, who had spoken with many area growers while conducting workshops for the nonprofit Community Alliance with Family Farmers (CAFF), reported that many were asking how they might better market their products.

To Vasconcellos, the time seemed right to approach California consumers with messages about how they could convert a growing interest in food to supporting local farmers. If consumers were willing to pay for open spaces by supporting local producers, why not help connect growers and consumers by branding their food, fiber and flowers as local?

With a farmer/rancher grant from SARE, Vasconcellos and the Central Coast RC&D designed and launched a Website, designed a “buy local” label and created a marketing structure that farmers could see working. The “Buy Fresh Buy Local” campaign was designed to reflect the wide array of products and the diversity of their operations, which included u-pick, farm stands and markets and such varied goods as alpaca fleeces, grass-fed beef and lamb, as well as fruit and vegetables.

“Buy local” campaigns are underway in many parts of the country. Nationally, the FoodRoutes Network

offers low-cost and customized publicity materials to help you or your group start a “buy local” campaign.

In remote rural areas, farmers banding together have strengthened market development. Ten farmers markets representing 150 small farms in western North Carolina joined forces to form the Mountain Tailgate Market Association (MTMA), bringing the power of a group behind promotion and performance. The term tailgate market, in fact, may be unique to the rural South, referring to lots and school yards where farmers drop their tailgates to reveal fresh-picked bounty. Since tailgate markets lean toward a show-up and set-up style, the small venues can be challenging to promote for farmers, many of whom have limited resources, as well as their small rural communities.

A SARE grant provided the resources to develop a logo for the association, conduct a multi-media promotional campaign, survey shoppers and vendors at all 10 markets, and conduct a workshop for the vendors. According to project leader Charlie Jackson, a farmer who is also on staff of the Appalachian Sustainable Agriculture Project, the SARE activities resulted in heightened visibility of the markets, brought many new customers, provided a strong base of information on customer and vendor perceptions of the markets and strengthened the cohesiveness of the group.

Surveys were particularly valuable, considering that about 1,600 customers and 60 vendors responded. The rapid feedback guided future promotional decisions. For example, the surveys indicated that most new

customers found the markets through word of mouth, so the vendors capitalized on that by asking customers to bring a friend on a particular market day designated as Summer Celebration. That day was the season's high point for traffic and sales.

"It's inspiring to see a group of farmers sitting down and planning together," Jackson says. "Group promotion is a major benefit of the association." That cooperation has led to plans for a 100-vendor market in Asheville, N.C.

INTERNET

AS INTERNET SALES CONTINUE TO GROW, CREATIVE FARMERS are jumping on board. The convenience of Web shopping appeals to today's busy consumers looking for unique products. The good news: You don't need to be a copywriter or a computer expert to tap into millions of potential buyers, although maintaining a successful Website can be challenging and time-consuming. Website design services have gotten more affordable in recent years, so contracting this out may make sense.

Even if you don't plan to sell your products over the Internet or via mail order, hosting a Website describing your farm, your location, hours, seasonal availability and other information makes good business sense. More and more people use the Internet as an all-purpose research tool in place of phone directories, maps and guidebooks.

A Website is also a terrific place to tell your story, a tried-and-true marketing strategy. Have a friend or

relative with a knack for photography – or a local art student or newspaper photographer – capture images of you, your family, key employees, your products, and a scenic view of your farm or ranch. Include a short "about us" section describing your farm's history, goals and values. Remember that reporters and researchers rely on the Internet too! Having an accessible, easy-to-navigate Website can multiply your promotional opportunities later.

Maryland farmers Robin and Mark Way developed a Website as part of a multifaceted "branding" campaign for their diversified, pasture-based livestock operation, Rumbleway Farm. Along with the Website, Robin Way made business cards, brochures, T-shirts, and an attention-getting farm sign, all featuring the farm's signature yellow chicken outlined in green. Way even created her own farm "blog," a software tool that lets you post regular entries in a journal-type format to share news, recipes, or other ideas. Way asserts the Website and other measures have had a huge impact on business.

Marketing cooperatives can offer a broader range of retail products on a single Website, increasing traffic while saving on the cost of Website design and maintenance. Appalachian Spring Cooperative (see p. 15) tried other marketing avenues, but found the Internet among their most effective channels.

Participating in online information gateways can result in extra business. Nationally, localharvest.org lists close to 10,000 venues where farmers and ranchers sell their products. The Maryland Extension Service, with help from a SARE grant, expanded an Internet-based sheep and goat marketing project begun in the Northeast to include the mid-Atlantic states. The new Website, www.sheepgoatmarketing.info, includes producer and processor directories as well as other resources such as a calendar of relevant religious holidays.



FEATURED FARM/RANCH WEBSITES:

- Appalachian Spring Coop, www.apspringcoop.com
- Buffalo Groves, Inc., www.buffalogroves.com
- Chico Basin Ranch, www.chicobasinranch.com
- Full Belly Farm, www.fullbellyfarm.com
- Persimmon Hill Farm, www.persimmonhill.com
- Rumbleway Farm, www.rumblewayfarm.com
- Texas Organic Cotton Marketing Cooperative, www.organicessentials.com
- Walters' Pumpkin Patch, www.walterspumpkinpatch.com.
- Wholesome Harvest, www.wholesomeharvest.com

A SARE-supported project in New England found that farmers could grow and crush canola for both meal and biodiesel, which brought a competitive price.

The Website “helps me put buyers and sellers in contact,” says project leader Susan Schoenian, who hopes to add nationwide listings. “All of the producers I come into contact with credit the site with helping them to sell breeding stock and meat animals.”

Many state departments of agriculture now maintain online directories of organic farms, pick-your-own farms and farm stands. Make sure your farm is included on these, and if possible, feature your Web address in your listing. Having links to your Website appear on other sites will improve your ranking among results returned by Internet search engines.

You can also drive traffic to your Website by gathering customers’ e-mail addresses and then sending weekly or monthly e-mail announcements to advertise new products, special events or seasonal offerings.

Now that Internet marketing has proliferated, online competition for consumers’ attention is fierce. Attracting buyers can be difficult when hundreds of other farmers offer similar products in catalogs or Websites. To stay in the game, you need to maintain a good Website. If it’s not current, a customer will zip away with a click of the mouse.

If you’re interested in investigating the potential of mail or Internet marketing, keep in mind:

- When it comes to effective design, less can be more. Resist the temptation to overload your Website with flashing banners and fancy fonts.
- Once you have a great Website, you still have to attract users. Strive to get a good ranking on search engines like Google by driving people to your site from online links and e-mail alerts. Good Web designers know how to improve your ranking by using keywords. Having a distinctive farm name can also be a plus.
- List your Web address and other information in online directories that strive to connect farmers and consumers, such as localharvest.org, eatwellguide.org and eatwild.com. Most of these sites are eager for new listings and will allow to you to create a customized entry free of charge.
- Update your Website often with your latest product information and news about the farm.
- Make sure the site is secure for credit-card users, and provide regular and toll-free numbers for customers who prefer to use the phone.
- Find reliable and cost-effective shippers who will deliver products on time in good condition.

RENEWABLE ENERGY

FARMERS GROWING GRAINS AND OILSEEDS MAY FIND NEW markets if interest in bio-based fuels continues to grow. Ethanol and biodiesel processing plants are increasingly common in the Midwest, while smaller-scale projects are being tested in the Northeast and other areas.

A SARE-supported project in Maine and Vermont found that farmers could grow and crush canola for \$293 per ton, yielding 1,180 pounds of meal and 92 gallons of oil. Including the income from sale of the meal, the break-even price of the biodiesel processed from the canola oil came out at \$3.09/gallon – a competitive price for a renewable fuel.

“Farmers are interested in producing a crop whose value is tied to the price of fuel,” says project leader Peter Sexton. “There’s also a great deal of personal satisfaction to be gained from producing your own fuel.”

While it’s hard to say exactly how the renewable fuels market will develop in coming years, with processing technologies improving and demand on the rise, fuel-crop production offers an array of opportunities for creating value-added products.

Installing photovoltaic panels or wind turbines, can reduce energy expenses over the long term and provide additional interest for farm visitors. See www.sare.org/coreinfo/energy.htm for more information about farm-based renewable energy.

EVALUATING NEW FARM ENTERPRISES

WHETHER YOU’RE LAUNCHING A NEW FARM BUSINESS OR retooling an existing one, analyzing all of your possibilities is crucial to the success of your venture. Consider writing a business plan, a road map that specifies your priorities, goals and objectives. Moreover, business plans provide a framework for reviewing your progress and pointing out the need for mid-course corrections.

If you want to undertake business planning, consider using *Building a Sustainable Business: A Planning Guide for Farmers and Rural Business Owners* (RESOURCES, p. 20), a 280-page guide to planning, implementation and evaluation. The book, co-published by SARE’s Sustainable Agriculture Network, includes dozens of worksheets to help you navigate the process.

With an existing farm operation, you should be able to do a basic enterprise analysis using the records you have to keep for tax purposes, says Seth Wilner, a county extension agent with the University of New Hampshire. “Look at your profitability, then look for anomalies. Maybe you thought blueberries were a profit center, say, but they’re not. So maybe you should shift things around.”

TRYING A NEW VENTURE? FIRST, MAKE A SOLID PLAN...

Before Earnie and Martha Bohner, farmers since 1982, launch value-added products, they analyze all the costs and benefits. After starting their farm with two acres of blueberries, they added other small fruits, then began processing them. Today, they cultivate 7 acres in Lampe, Mo., and enjoy a comfortable income. Yet, they adopted each new enterprise only after asking a series of soul-searching questions, such as:

- Will the product fit in with the farm operation?
- Is the product consistent with the farm's mission and purpose?
- Will the product be economically sustainable?

In 2004, they explored freeze-drying shiitake mushrooms as a new way to add value. Armed with a SARE farmer grant, Earnie plunged into research. He found an inexpensive dryer, but it required a prohibitive amount of energy to operate, a cost he needed to justify with a

lucrative end product.

When he ran the costs – raw product, packaging, bags, labels, packing and shipping – he found that the freeze-drying was considerably more expensive than air-drying, a distinction that might be lost on customers.

Earnie ran the numbers on further processing the mushrooms into soup mix, adding still more value. Drying the mushrooms off site brought down their costs, and they could charge enough for a premium soup mix to more than offset them. The Bohners debuted the soup mix in 2006 to an enthusiastic response.

What's next? More planning as the couple attempts to move into wholesale marketing of shiitakes.

"After evaluation in three to four test markets, we will be better able to make an economically sound decision as to whether we can justify building our own freeze-drying facility," Earnie says.



Martha Bohner

You might consider seeking outside help with a specific element of your plan, like marketing. For a medium-sized direct marketing farm business, working with a marketing consultant will typically cost between \$1,000 and \$3,000. Hiring a consultant is a good idea if you're not sure how to get started or if you lack the time to go through the process on your own. "It's definitely a worthwhile investment if you're in the retail market," Wilner says. "It's a lifetime investment."

Failure to judge the true demand for a product is a common cause of failure in many business ventures. To improve your odds, be thorough about your market research. Good research entails finding out as much as possible about your planned products or services. Investigate as many marketing options as possible and identify several that look promising. The more ways and places you have to sell your product, the better your chances of success.

Promotion and customer relations should be part of your marketing plan. A common rule of thumb for promotional expenses is 3 percent of projected sales.

In New Hampshire, Wilner helped three farms improve their bottom line by working with a marketing consultant, partly with a SARE grant aimed at building marketing skills for both farmers and county Extension.

For example, Beaver Pond Farm, a well-established farm near Newport, N.H., specializing in pick-your-own

raspberries, used the consultant's advice to improve signage, raise prices on some items and adjust the layout of their farm stand to improve product visibility. They planted blueberries to diversify their crop mix and began selling meat, apples, cheeses and milk from other local farms in addition to their own products.

"People want more one-stop shopping. The customers haven't batted an eye on the price hikes," Wilner says. "The farm's gone from breaking even or maybe losing a little money to having two good seasons."

Marketing activities are guided by a variety of regulations at federal, state, county and municipal levels. Some vary by type of enterprise and location, while others are more general. Legal considerations include the type of business ownership (sole proprietorship, partnership, etc.), zoning ordinances, small business licenses, building codes and permits, weights and measures, federal and state business tax issues, sanitation permits and inspections, food processors' permits and more. For more information, consult the *Legal Guide for Direct Farm Marketing* (RESOURCES, p. 20).

Adequate insurance coverage is essential. Every operator should have liability insurance for products and premises, employer's liability, and damage insurance to protect against loss to buildings, merchandise and other property. Ask your insurance agent about liability and loss insurance specifically designed for direct-market farmers.

Resources

GENERAL INFORMATION

Sustainable Agriculture Research and Education (SARE) program.

SARE studies and spreads information about sustainable agriculture via a nationwide grants program and practical publications. (301) 504-5230; sare_comm@sare.org; www.sare.org. See the *Direct Marketing Resource Guide* at www.sare.org/publications/dmrg.htm.

Alternative Farming Systems Information Center (AFSIC).

Provides on-line information resources, referrals and searching on alternative marketing topics. (301) 504-6559; afsic@nal.usda.gov; www.afsic.nal.usda.gov. See comprehensive directory, *Organic Agricultural Products: Marketing and Trade Resources*, www.nal.usda.gov/afsic/AFSIC_pubs/OAP/srb0301.htm, or request free CD.

Agricultural Marketing Resource Center.

Information resources for value-added agriculture. www.agmrc.org.

Agricultural Marketing Service (AMS), USDA.

Information on direct markets, funding sources and publications about sales to schools/restaurants. www.ams.usda.gov/tmd/MSB/publications.htm.

ATTRA.

National information service offers 200+ free publications. Call (800) 346-9140; Spanish: (800) 411-3222; or go to <http://attra.ncat.org> for:
– *Direct Marketing Business Management Series*
– *Adding Value to Farm Products: An Overview*
– *Fresh to Processed: Adding Value for Specialty Markets*
– *Bringing Local Food to Local Institutions.*

Growing for Market.

National monthly newsletter for direct market farmers. \$30/yr. growing4market@earthlink.net; (800) 307-8949; www.growingformarket.com.

North American Farmers' Direct Marketing Association,

Southampton, MA (413) 529-0386 or (888) 884-9270; www.nafdma.com.

FARMERS MARKETS/AGRITOURISM

Agritourism and Nature Tourism in California

by University of California, Davis. <http://ucce.ucdavis.edu/files/filelibrary/5327/3866.pdf>.

Center for Agribusiness and Economic Development.

Lists publications on running farm-stands, promoting "agri-tainment," etc. www.caed.uga.edu.

Direct Farm Marketing and Tourism Handbook

by the University of Arizona. <http://ag.arizona.edu/arec/pubs/dmkt/dmkt.html>.

Farmers Market Promotion Program.

Grants program from USDA's Agricultural Marketing Service for farmers markets, roadside stands, CSA. www.ams.usda.gov/farmersmarkets/FMPP/FMPPInfo.htm. Also see *Farmers Market Consortium Resource Guide*, www.ams.usda.gov/farmersmarkets/Consortium/ResourceGuide.htm.

Managing the Liability and Risks of Farm Direct Marketing and Agritourism

by USDA's Risk Management Agency. Resources for understanding and analyzing potential liability risks. http://www.communityagcenter.org/Risk_Liability/Risk_Introduction.htm.

Market Decision Making Toolbox for Farmers Markets.

Michigan Food & Farming System. www.miffsmarketline.org/projects/green.html.

Resources for Farmers Markets

by the Northeast/Midwest Institute. Includes market locators and funding sources. www.farmersmarketsusa.org.

The New Farmers' Market: Farm-Fresh Ideas For Producers, Managers & Communities

by Eric Gibson. Tips for farmers and market managers and city planners. \$24.95 + \$3.95. www.sare.org/publications/newfarmer.htm; (301) 374-9696.

Sharing the Harvest: A Guide to Community-Supported Agriculture

by Elizabeth Henderson with Robyn Van En. Lays out the basic tenets of CSA for farmers and consumers. 270 pp; \$24.95. (800) 639-4099; www.chelseagreengarden.com.

Tourism & Community Development Resources & Applied Research

Clearinghouse, University of Wisconsin, Madison. www.wisc.edu/urpl/people/marcouiller/projects/clearinghouse/Tourism%20Resources.htm.

DIRECT MARKETING MEAT AND ANIMAL PRODUCTS

CSU Chico Grass-Fed Beef Website.

Includes research articles reviewing the documented health benefits of grass-fed beef, information on how to create a label for your meat that complies with federal regulations, recipes and more. www.csuchico.edu/agr/grassfedbeef.

Farm Fresh: Direct Marketing Meats and Milk

by Allan Nation. Answers to how, how much, when, or where to sell grass-fed meat or milk for the highest profits. 251 pp; \$35.60. www.stockmangrassfarmer.net/cgi-bin/page.cgi?id=361.html.

How to Direct Market Your Beef

by the Sustainable Agriculture Network. Practical tips for selling grass-raised beef to direct markets. 96 pp; \$14.95. www.sare.org/publications/beef.htm; (301) 374-9696.

VALUE-ADDED PRODUCTS/PROCESSING/SELLING DIRECT

Farmers and their Diversified Horticultural Marketing Strategies

by the Center for Sustainable Agriculture. 48-minute video, \$15. www.uvm.edu/vtvegandberry/Videos/marketvideo.htm; (802) 656-5459.

Food Marketing & Processing Food Map.

A comprehensive clearinghouse of marketing and processing information on identifying new markets, locating processing equipment, etc. www.foodmap.unl.edu.

Safe Sell Dairy: Creative Ways to Sell Dairy Products at Farmer's Markets

by Courtney Haase. Product presentation, sampling and good market etiquette. 76 pp.; \$8. www.nunsuch.org/safesell.htm.

Selling Directly to Restaurants and Retailers by UC-SAREP.

Tips for a successful, entrepreneurial relationship with local restaurants, retailers. www.sarep.ucdavis.edu/cdpp/selldirect.pdf.

BUSINESS PLANNING & MANAGEMENT

Building a Sustainable Business: A Guide to Developing a Business Plan for Farms and Rural Businesses,

by the Minnesota Institute for Sustainable Agriculture and the Sustainable Agriculture Network. A guide for agricultural entrepreneurs. 272 pp; \$17 + s/h. www.sare.org/publications/business.htm; (301) 374-9696.

Farming Alternatives: A Guide to Evaluating the Feasibility of New Farm-Based Enterprises

(NRAES-32). \$8 + \$3.75 s/h to Natural Resource, Ag & Engineering Service. http://extensionpubs.umext.maine.edu/ePOS/form=robots/item.html&item_number=1036&store=413&design=413; (607) 255-7654.

The Legal Guide for Direct Farm Marketing

by Neil Hamilton. Tips about legal issues when direct-marketing farm products. \$20 + \$3 s/h to Agricultural Law Center, Drake University. www.amazon.com; (515) 271-2947.

New Farm Options

University of Wisconsin Extension. New niche markets and business start-up issues. www.uwex.edu/ces/agmarkets.

NxLevel

This agricultural entrepreneurs program module offers in-depth training and materials for farmers seeking marketing opportunities. www.nxlevel.org; info@nxlevel.org; (800) 873-9378.

USDA Rural Business and Cooperative Programs.

Supports cooperatives in areas such as marketing. www.rurdev.usda.gov/rbs; (202) 720-7558.

SARE works in partnership with Extension and Experiment Stations at land grant universities to deliver practical information to the agricultural community. Contact your local Extension office for more information.

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**Direct Marketing:
Business Management Series**

(Merge protected. Find at: <http://attra.ncat.org/attra-pub/PDF/directmkt.pdf>)

Direct Marketing: Business Management Series (Katherine Adam, Radhika Balasubrahmanyam & Holly Born, November 1999, ATTRA)